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NATO Allied Medical Publication 7.5 Study Draft 2 (AMedP-7.5 SD.2), "NATO Planning Guide for the Estimation of CBRN Casualties"

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14. ABSTRACT

This document is the second in a series of developmental draft documents leading to AMedP-7.5(A), the next iteration of the NATO CBRN casualty estimation methodology. This document presents the methodology as comprising four components???user input, estimation of the CBRN challenge, estimation of human response, and casualty estimation and reporting. This document fully describes the required inputs, the method of calculating the CBRN challenge, and the estimation and reporting of human response and casualties, including a dedicated section for each agent/effect describing how to estimate human response and casualties from that specific agent/effect. To increase user-friendliness, each dedicated section contains a flowchart for that agent effect instructing the user on which equations and lookup tables should be used, and the sequence in which they should be used. As this is a Study Draft, it has a few placeholders for agent-specific models, where model development or revision is ongoing. The final document will include 8 chemical agents, 17 biological agents, nuclear effects, radiological dispersal device isotopes, radiological fallout, and several illustrative examples.

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NATO PLANNING GUIDE FOR THE ESTIMATION OF CBRN CASUALTIES

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NATO LETTER OF PROMULGATION

[Date]

1. The enclosed Allied Medical Publication AMedP-7.5, NATO Planning Guide for the Estimation of CBRN Casualties, which has been approved by the nations in the [TA], is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG XXXX.

2. AMedP-7.5(A) is effective upon receipt/will come into effect on [NED] and supersedes AMedP-8(C) which shall be destroyed in accordance with the local procedure for the destruction of documents.

4. This publication shall be handled in accordance with C-M(2002)60.

Edvardas MAŽEIKIS
Major General, LTUAF
Director, NATO Standardization Office

RESERVED FOR NATIONAL LETTER OF PROMULGATION

RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS

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RECORD OF SPECIFIC RESERVATIONS

[nation]	[detail of reservation]

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CHAPTER 1 DESCRIPTION OF THE METHODOLOGY

1.1. INTRODUCTION AND DOCUMENT ORGANIZATION

1. AMedP-7.5 provides a methodology for estimating casualties that occur over time following a chemical, biological, radiological, or nuclear (CBRN) incident.

2. The methodology begins by estimating each individual's CBRN challenge[1] resulting from a user-postulated CBRN incident. Human response to these agents and effects, as a function of the type and magnitude of CBRN challenge and CBRN countermeasures, is represented by Injury Profiles—descriptions of changing injury severity over time. Casualty status is then defined as a function of a user-specified casualty criterion.

3. The organization of this document is intended to facilitate understanding and implementation of the methodology.

a. Chapter 1 explains the terms and concepts underlying the methodology, describes in general terms how the inputs are used to generate the casualty estimate, and provides references to other NATO documents describing how the outputs may be used.

b. Chapter 2 fully describes the required and optional input (with examples), and describes how the utility of the output is affected by the user input.

c. Chapter 3 describes the general process and equations used to estimate each individual's CBRN challenge.

d. Chapters 4 and 5 fully describe the human response and casualty estimation processes for all included agents and effects, including all necessary equations and tables, and flowcharts that explicitly state the sequence of equations and tables necessary to estimate human response and casualties.

e. Chapter 6 describes how the casualty estimates from Chapters 4 and 5 are summed and reported in accordance with NATO standards.

f. Annex A provides step-by-step illustrative examples for applying the methodology.

[1] In this document, "CBRN challenge" means an amount or degree of CBRN agent or effect. See section 1.4 for additional definitions.

4. This document is supplemented by an associated Standards Related Document (SRD) that contains:

a. Detailed reasoning behind the analytic decisions, assumptions, limitations, and constraints built into the methodology.

b. For each agent and effect, the derivation, presentation, and supporting reasoning for the parameter values, lookup tables, assumptions, limitations, constraints, and the symptom progressions underlying the composite Injury Profiles presented in this document.

c. A list of the references used in the development of this methodology and its human response models.

1.2. PURPOSE AND INTENDED USE

1. The purpose of this document is to describe a methodology for estimating casualties uniquely occurring as a consequence of CBRN incidents near Allied forces, in support of the planning processes described in Allied Joint Publication 3.8 (AJP-3.8), *Allied Joint Doctrine for NBC Defence*,[2] Allied Joint Publication 4.10 (AJP-4.10), *Allied Joint Medical Support Doctrine*,[3] Allied Joint Medical Publication 1 (AJMedP-1), *Allied Joint Medical Planning Doctrine*,[4] Allied Joint Medical Publication 7 (AJMedP-7), *Allied Joint Medical Doctrine for Support to CBRN Defensive Operations*,[5] and Allied Medical Publication 7.6 (AMedP-7.6), *Commander's Guide to Medical Support in Chemical, Biological, Radiological, and Nuclear Environments*.[6]

2. The purpose of the methodology is to estimate the number, type, severity, and timing of CBRN casualties.

3. The purpose of the casualty estimate is to assist planners, logisticians, and other staff officers by allowing for more effective quantification of contingency

[2] North Atlantic Treaty Organization (NATO), *AJP-3.8(A): Allied Joint Doctrine for CBRN Defence*, STANAG 2451 (Brussels: NATO, 30 March 2012).

[3] North Atlantic Treaty Organization (NATO), *AJP-4.10(A): Allied Joint Medical Support Doctrine*, STANAG 2228 (Brussels: NATO, 3 March 2006).

[4] North Atlantic Treaty Organization (NATO), *AJMedP-1: Allied Joint Medical Planning Doctrine*, STANAG 2542 (Brussels: NATO, 3 November 2009).

[5] North Atlantic Treaty Organization (NATO), *AJMedP-7: Allied Joint Medical Doctrine for Support to CBRN Defensive Operations Study Draft 4*, STANAG 2596 (Brussels: NATO, February 2014).

[6] North Atlantic Treaty Organization (NATO), *AMedP-7.6: Commander's Guide to Medical Support in Chemical, Biological, Radiological, and Nuclear Environments*, STANAG 2596 (Brussels: NATO.

requirements for medical force structure, specialty personnel, medical materiel, and patient transport or evacuation. Some example users and the uses to which they might put the output are:

a. Operational planners may use casualty estimates to provide coordinating instructions to units or to assess unit casualty distributions when evaluating courses of action resulting from variations in a number of parameters, such as medical countermeasures (e.g. prophylaxis). Allied Joint Publication 5 (AJP-5), Allied Joint Doctrine for Operational-Level Planning,[7] provides information for operational planners.

b. Logistics planners may use casualty estimates to determine logistical requirements, both medical and non-medical, for the management of CBRN casualties. Allied Joint Publication 4 (AJP-4), Allied Joint Logistic Doctrine,[8] provides information for logistics planners.

c. Personnel planners may use casualty estimates to determine personnel replacement requirements.

d. Medical planners may use casualty estimates to identify medical resource requirements, such as pharmaceuticals, medical devices, medical supplies, bed types, and personnel specialties, for each role of medical treatment. Commanders, Medical Advisors, and Medical Directors may also use casualty estimates to evaluate medical courses of action. AMedP-7.6 and AJP-4.10 provide further information about planning for medical operations in CBRN environments.

4. The methodology described herein is proposed solely for deliberate planning and is not intended for real-time or dynamic use. Moreover, it is not intended for use in deployment health surveillance or for any post-incident uses including diagnosis, medical treatment, or epidemiology.

1.3. SCOPE

This document includes information necessary to estimate acute human response to a specific set of CBRN agents and effects. This set is not exhaustive, and other agents or effects could be incorporated at a later time as permitted by the availability of adequate, credible data.

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[7] North Atlantic Treaty Organization (NATO), *AJP-5: Allied Joint Doctrine for Operational-Level Planning*, STANAG 2526 (Brussels: NATO, 26 June 2013).

[8] North Atlantic Treaty Organization (NATO), *AJP-4(A): Allied Joint Logistics Doctrine*, STANAG 2182 (Brussels: NATO, 9 March 2004).

1.3.1. Challenge Types

1. The phrase “challenge type” is used in several ways in this document.

   a. It can be a generic descriptor, at the level of “chemical,” “biological,” “radiological,” or “nuclear.”

   b. It can be slightly more specific by including the route of exposure, such as “inhaled chemical agent” or “nuclear blast.”

   c. For chemical and biological agents, it can refer to the specific agent and route of exposure, such as “inhaled GB” or “inhaled *B. anthracis*.”

2. Chemical agents considered include two nerve agents, sarin (GB) and VX, a blister agent, distilled mustard (HD), two pulmonary agents, phosgene (CG) and chlorine (Cl_2), and three blood agents, hydrogen cyanide (AC), cyanogen chloride (CK), and hydrogen sulfide (H_2S).

Table 1-1: Chemical Agent Challenge Types

Agent	Inhalation	Percutaneous Vapor	Percutaneous Liquid
GB	X		
VX	X	X	
HD	X	X	X
CG	X*		
Cl_2	X		
AC	X		
CK	X*		
H_2S	X		

* Inhalation is considered in two ways: concentration time and peak concentration. See sections 4.2.5 and 4.2.6 for further details.

3. Biological agents considered include the causative agents of anthrax, brucellosis, Eastern equine encephalitis (EEE), Ebola Virus Disease (EVD), glanders, Marburg Virus Disease (MVD), melioidosis, plague, Q fever, smallpox, tularemia, Venezuelan equine encephalitis (VEE), and Western equine encephalitis (WEE). Diseases caused by the biological toxins botulinum neurotoxin, ricin, staphylococcal enterotoxin B (SEB), and T-2 mycotoxin are also considered.

   a. Inhalation is the only challenge type considered for biological agents.

   b. Although non-contagious models are provided for every disease/agent listed above, the methodology includes alternate models that consider the spread of contagious disease for EVD, MVD, pneumonic plague, and smallpox.

4. Radiological agents are modeled for two source types: radiological dispersal devices (RDDs) and radioactive fallout resulting from a nuclear detonation.

a. RDDs.

1) The radioisotopes modeled are ^{60}Co, ^{90}Sr, ^{131}I, ^{137}Cs, ^{192}Ir, ^{238}Pu, and ^{241}Am.

2) Whole-body irradiation (from cloudshine and groundshine[9]) and cutaneous radiation (from skin contamination, cloudshine, and groundshine) are the challenge types considered.

b. Fallout.

1) Radioactive fallout deposited on the ground is not isotope-specific.

2) Whole-body irradiation (from groundshine only) and cutaneous radiation (from skin contamination and groundshine) are the challenge types considered.[10]

5. Prompt nuclear effects considered are:

a. Whole-body external irradiation from initial ionizing radiation (gamma and neutron radiation).

b. Primary blast effects (barotrauma) due to static overpressure, and lethal tertiary blast effects (whole-body translation coupled with decelerative tumbling) due to dynamic pressure (winds).

c. Partial thickness burns to skin due to thermal fluence.

6. Battle stress (also commonly referred to as “psychological”) and indirect effects (e.g., injuries resulting from car accidents following an incident, burns due to secondary fires, or opportunistic infections) are not considered.

1.3.2. Types of Casualty

The methodology estimates casualties with regard to the *medical* system, not the *personnel* system. Thus, it estimates killed in action (KIA), wounded in action (WIA), died of wounds received in action (DOW), convalescent (CONV), and return to duty (RTD) casualties, but does not estimate detained, captured, or missing casualties; for definitions of the included casualty categories, see section 1.4.

[9] Cloudshine and groundshine are radioactive material in the air and on the ground, respectively.

[10] Note the exclusion of cloudshine, which confers the assumption that the fallout cloud has settled.

1.3.3. Countermeasures

The methodology can account for the following types of countermeasures, which can provide the listed types of protection; for definitions, see section 1.4.

a. Individual protective equipment (IPE).

   1) Inhalation protection.

   2) Percutaneous liquid and vapor protection.

b. Physical protection.

   1) Inhalation and percutaneous vapor protection.

   2) Percutaneous liquid protection.

   3) Gamma ray shielding.

   4) Neutron shielding.

   5) Blast shielding.

   6) Thermal shielding.

c. Collective Protection (ColPro).

   1) Inhalation and percutaneous vapor protection.

   2) Percutaneous liquid protection.

d. Medical countermeasures.

   1) Dependent on the specific countermeasure.

1.4. DEFINITIONS

1. Population at Risk (PAR): a group of individuals considered at risk of exposure to conditions which may cause injury or illness.[11] For this methodology, this is always the total number of personnel in the scenario, and is defined by user input.

[11] Note that this definition differs from AMedP-13(A), which says that all individuals in the PAR are exposed: See North Atlantic Treaty Organization (NATO), *AMedP-13(A): NATO Glossary of Medical Terms and Definitions*, STANAG 2409 (Brussels: NATO, 6 May 2011), 2-49.

2. Icon: a group of individuals sharing a common location over time. Each icon is given a unique numerical identifier and is associated with a set of attributes that is used to estimate what fraction of the CBRN Challenge will become the Effective CBRN Challenge (terms defined below).

3. CBRN Challenge:

   a. The time-varying cumulative amount or degree of CBRN agent or effect estimated to be present in the physical environment with which icons are interacting.

   b. For chemical agents with concentration-based effects, also includes the time-dependent gas concentration estimated to be present in the physical environment with which icons are interacting.

4. Effective CBRN Challenge: the cumulative amount or degree of CBRN agent or effect that is estimated to actually affect an icon, after accounting for the icon's attributes. Used as input to the human response portion of the methodology. Per Table 1-2, this term is broadly used within the methodology to encompass a range of phenomena, the specific expression of which depends on the challenge type.

Table 1-2: Challenge Types and Associated Terminology

Challenge Type	Specific Terminology for Effective CBRN Challenge
Inhaled Chemical Agent* Vapor	Inhaled concentration time (Ct) Inhaled peak concentration
Percutaneous Chemical Agent* Vapor	Percutaneous vapor concentration time (Ct)
Percutaneous Chemical Agent* Liquid	Percutaneous liquid dose
Inhaled Biological Agent*	Inhaled dose
RDD or Fallout	Whole-body dose Cutaneous dose
Initial Ionizing Radiation (Nuclear)	Whole-body dose
Blast (Nuclear)	Blast insult[12]
Thermal (Nuclear	Thermal insult

* Challenge types include the specific chemical or biological agent name. Thus, example challenge types are Inhaled GB Vapor and Inhaled *B. anthracis*.

5. Individual protective equipment (IPE): "In chemical, biological, radiological and nuclear defence, the personal equipment intended to physically protect an individual from the effects of chemical, biological, radiological and nuclear substances."[13]

[12] An insult is "anything which tends to cause disease in or injury to the body or to disturb normal bodily processes," per Oxford English Dictionary Online, s.v. "insult," accessed October 4, 2013, http://www.oed.com/view/Entry/97243.

[13] NTMS, NATO Agreed 2014-04-10.

6. Physical protection: In chemical, biological, radiological and nuclear defence, a vehicle or shelter that protects an individual from the effects of chemical, biological, radiological and nuclear substances.

7. Collective Protection (ColPro): “Protection provided to a group of individuals in a chemical, biological, radiological and nuclear environment, which permits relaxation of individual chemical, biological, radiological and nuclear protection.”[14]

8. Medical Countermeasures: “Those medical interventions designed to diminish the susceptibility of personnel to the lethal and damaging effects of chemical, biological, and radiological hazards and to treat any injuries arising from challenge by such hazards.”[15] This document extends the definition to include nuclear hazards.

a. Prophylaxis: medical countermeasures administered before the onset of signs and symptoms (can be pre- or post-exposure).

b. Treatment: medical countermeasures administered after the onset of signs and symptoms.

9. Protection Factor: “A measure of the effectiveness of a protective device or technique in preventing or reducing exposure to chemical, biological, radiological and nuclear substances, or of a medical treatment in preventing or reducing the physiological effects of such substances.”[16] In this document, a protection factor is the factor by which the CBRN Challenge is reduced; for example, a mask protection factor of 10 reduces an inhaled *B. anthracis* dose from 100 spores to 10 spores. Protection factors are used to model the effects of IPE, physical protection, ColPro, and pre-exposure prophylaxis against CRN challenges.

10. Aggregate Protection Factor (APF): a single protection factor used to represent all relevant[17] protection factors for an icon (based on icon attributes). Computed by multiplying all relevant protection factors, per Equation 2-2.

11. Icon attributes: a list of an icon’s identifying information and challenge-modifying attributes with associated protection factors. Challenge-modifying attributes and associated protection factors can change over time, as specified by the user. Default values are provided in Chapter 2.

[14] NTMS, NATO Agreed 2009-08-26.

[15] NTMS, Not NATO Agreed 2006-07-01.

[16] NTMS, NATO Agreed 2014-04-10.

[17] Which protection factors are relevant depends on the challenge type.

12. Injury: general term that includes both wounds and disease.[18] Injuries may be caused by chemical, biological, radiological, radiation, blast, and thermal challenges.

13. Injury Severity Level: the degree of injury caused by the Effective CBRN Challenge, characterized by five integer levels and corresponding qualitative descriptions, as defined in Table 1-3. The definitions are expanded from those provided in AMedP-13 to include both medical requirements and operational capability.

14. Injury Profile: a tabular description of the progression of injury, expressed in terms of the step-wise Injury Severity Level changes over time, with time "zero" defined as the time at which the Effective CBRN Challenge stops accumulating.[19] Injury Profiles only show time points at which the Injury Severity Level changes. In some cases, the last entry in an Injury Profile is non-zero, in which case it is assumed that full recovery never occurs.

15. Composite Injury Profile: an Injury Profile generated by overlaying multiple Injury Profiles and selecting the maximum Injury Severity Level at each time point.

16. Casualty Criterion: the user-specified injury severity level used to determine whether an individual is wounded in action (WIA). The syntax and more specific definition for each of the possible choices for the casualty criterion are:[20]

a. WIA(1^+): an individual manifesting signs and/or symptoms of Severity Level 1 or greater is considered WIA.

a. WIA(2^+): an individual manifesting signs and/or symptoms of Severity Level 2 or greater is considered WIA.

b. WIA(3^+): an individual manifesting signs and/or symptoms of Severity Level 3 or greater is considered WIA.

[18] This is consistent with the usage found in AAP-6: North Atlantic Treaty Organization (NATO), *AAP-6: NATO Glossary of Terms and Definitions*, STANAG 3680 (Brussels: NATO, 29 April 2014), 2-W-2.

[19] The implied assumption, specifically stated in section 1.5, is that each icon is assumed to have received its entire Effective CBRN Challenge prior to the onset of any symptoms.

[20] Note that since "Severe" symptoms are defined as those which preclude an individual's ability to conduct the assigned mission, a casualty criterion of WIA(4^+) is not allowed.

Table 1-3: Injury Severity Level Definitions

	Degree	Description
0	N.O.E.	Although some exposure to an agent or effect may have occurred, no observable injury (as would be indicated by manifested symptoms) has developed; alternately, recovery from a prior injury is complete.
1	Mild	Injury manifesting symptoms (and signs for biological agents) of such severity that individuals can care for themselves or be helped by untrained personnel; condition may not impact ability to conduct the assigned mission
2	Moderate	Injury manifesting symptoms (and signs for biological agents) of such severity that medical treatment may be required; general condition permits treatment as outpatient and some continuing care and relief of pain may be required before definitive care is given; condition may be expected to interrupt or preclude ability to conduct the assigned mission
3	Severe	Injury manifesting symptoms (and signs for biological agents) of such severity that there is cause for immediate concern but there is no imminent danger to life; individual is acutely ill and likely requires hospital care. Indicators are questionable – condition may or may not reverse without medical intervention; individual is unable to conduct the assigned mission due to severity of injury
4	Very Severe	Injury manifesting symptoms (and signs for biological agents) of such severity that life is imminently endangered. Indicators are unfavorable – condition may or may not reverse even with medical intervention; prognosis is death without medical intervention; individual is unable to conduct the assigned mission due to severity of injury

* N.O.E. = No Observable Effect.

1.4.1. Types of Casualty

1. Casualty: "With regard to the medical system, a person who is lost to an organization by reason of having been declared dead, wounded, injured, or diseased."[21]

2. Chemical casualty: "A casualty caused by exposure to a chemical substance."[22]

3. Biological casualty: "A casualty caused by exposure to a biological agent."[23]

4. Radiological casualty: "A casualty caused by exposure to ionizing radiation."[24]

5. Nuclear casualty: "A casualty caused by exposure to nuclear flash, blast, heat,

[21] NTMS, NATO Agreed 2013-05-14.

[22] NTMS, NATO Agreed 2014-06-25.

[23] Although this definition is consistent with the definitions for chemical, radiological, and nuclear casualty, as of 2014-09-19 it is only a proposed definition, and is awaiting confirmation, per NATO NSO TTF Tracker 2012-0029, "biological casualty." There is no NTMS entry for "biological casualty."

[24] NTMS, NATO Agreed 2014-06-25.

or radiation."[25] Flash blindness is not considered in this document.

6. Wounded in Action (WIA): "a battle casualty other than 'killed in action' who has incurred an injury due to an external agent or cause as a result of hostile action. Note: The term encompasses all kinds of wounds and other injuries incurred in action, whether there is a piercing of the body, as in a penetrating or perforated wound, or none, as in the contused wound; all fractures, burns, blast concussions, all effects of biological and chemical warfare agents, the effects of exposure to ionizing radiation or any other destructive weapon or agent."[26]

7. Killed in Action (KIA): "a battle casualty who was killed outright or who died before reaching a medical treatment facility."[27] By definition, in this document, a KIA was previously WIA. Also by definition, as described in section 1.6.1.5.c, KIAs occur on the same day as the injury.

8. Died of Wounds received in action (DOW): "a battle casualty who died after having entered the medical care system."[28] To be consistent with the definition of KIA, "the medical care system" is taken to mean a Role 1 or higher Medical Treatment Facility (MTF); if a casualty dies during medical evacuation, he is considered KIA. By definition, in this document, a DOW was previously WIA.

9. Convalescent (CONV): a patient who is "mostly ambulatory [and] requires limited therapeutic intervention and administration of oral medications performed by the patient."[29] Thus, CONV refers to outpatient medical care; a CONV was previously WIA. In this methodology, casualties whose recovery time can be estimated will RTD; those with an unknown period of recovery or permanent disability will remain in CONV.

10. Return to Duty (RTD): "The administrative process of releasing a patient from medical treatment facility to his or her unit."[30] Thus, an RTD was previously WIA (and possibly CONV), but has recovered. This methodology does not consider the impact of theater evacuation policy on RTD—individuals in the RTD category are simply *available* to return to duty.

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[25] NTMS, NATO Agreed 2014-06-25.

[26] NATO, *AMedP-13(A)*, 2-65. Note that this definition differs from the NTMS, which states that a WIA "has incurred a non-fatal injury," thereby precluding the possibility that a WIA can later die—an incorrect definition.

[27] NTMS, NATO Agreed 2011-11-07.

[28] NTMS, NATO Agreed 2011-11-07.

[29] NATO, *AMedP-13(A)*, 2-15.

[30] NTMS, NATO Agreed 2014-06-25.

11. Casualty category: a group of casualties with a common prognosis and/or needing approximately the same level of medical treatment.[31] In the context of this document, the casualty category can be KIA, WIA, DOW, CONV, and RTD.

1.5. GENERAL ASSUMPTIONS AND CONSTRAINTS

1. Assumptions.

   a. Individuals are normally healthy—they have no pre-existing physiological injury or condition that would alter human response.

   b. Human response begins after the challenge ends—each icon receives its entire Effective CBRN Challenge prior to the onset of any symptoms, and there is a common "time zero" at which human response begins for every individual in the scenario.

   c. Parameter values derived from *animal models* are applicable to *human* response models and casualty estimation (in most cases, the animal model used was a non-human primate).

   d. Medical treatment facilities have unlimited resources.

3. Constraint. For inhalation challenges, the methodology uses an estimated inhaled challenge, rather than an estimated retained challenge.

1.6. SUMMARY OF THE METHODOLOGY

The five major steps of the methodology are listed below.

   a. INPUT: define icons, icon attributes, CBRN Challenge per icon over time,[32] and values of four methodology parameters. Must be provided by the user.

   b. CHALLENGE: estimate Effective CBRN Challenge per icon.

   c. RESPONSE: estimate distribution of human response in the PAR over time.

[31] The NTMS defines casualty category as "A group of casualties having the same type of injury and causation, as used in medical planning," and gives examples including KIA, WIA, and DOW (NATO Agreed 2011-11-07). This definition makes little sense, as there are many different reasons an individual might become KIA, WIA, or DOW. The definition used in this document follows the idea of the examples given by the NTMS by including CONV and RTD.

[32] Alternately, the user can provide the Effective CBRN Challenge per icon, in which case the second step is skipped.

d. STATUS: estimate distribution of casualties in the PAR over time.

e. REPORT: report the numbers of new and total casualties in each casualty category over time.

1.6.1. INPUT

1. The user must determine how personnel should be grouped into icons.

2. The user must provide either the CBRN Challenge per icon over time, or the Effective CBRN Challenge per icon. If multiple challenges[33] are to be modeled, separate input must be provided for each challenge.

3. If the user provides the CBRN Challenge per icon over time, the user should also provide input for the icon attributes, such that the estimate will better reflect the user's planning scenario.

a. For example, if the user provides appropriate input for the icon attributes, the methodology can reflect the impacts of icon movement, changes in breathing rate (e.g. due to sprinting to cover), and changing defensive postures (e.g. due to warning and response). Chapter 2 contains guidance on providing this input.

b. If no input is provided for icon attributes, default values will be used.

4. If the user provides Effective CBRN Challenge per icon, no other information is necessary—it is assumed that the user has already accounted for all relevant icon attributes.

5. The user must also determine whether to use default values or specify alternate values for four methodology parameters, discussed below, that affect the RESPONSE and STATUS steps.

a. Medical Treatment Flag ($Flag_{MT}$). A binary parameter that determines whether the methodology should include the effects of specific therapies that counteract specific injuries (e.g. antibiotics), where such therapies exist. If set to NO, the "Untreated" human response models, which reflect supportive care alone, are used. If set to YES, the "Treated" human response models, reflecting the available specific therapies, are used. The default value is YES.

[33] Multiple challenges can occur as a result of a single incident (nuclear detonation) or multiple incidents (e.g. GB and an RDD).

b. Time at Injury Severity Level 4 sufficient to cause death from untreated chemical, nuclear blast, or nuclear burn injuries ($T_{death\text{-}CN\text{-}SL4}$). Untreated[34] casualties with a chemical, nuclear blast, or nuclear burn injury that spend this threshold amount of time at Severity Level 4 are assumed to die. The default value is 15 minutes.

c. Time to reach a medical treatment facility (T_{MTF}). The time required for an individual who is WIA to reach a MTF. Given the definitions of KIA and DOW, T_{MTF} determines whether a WIA who dies is KIA or DOW (see Figure 1-2). The default value is 30 minutes, and a user can specify any value up to (but excluding) 1 day—the methodology is built around the assumption that casualties reach an MTF *within* one day of becoming WIA.

d. The casualty criterion. The user-specifiable injury severity threshold above which an individual is declared WIA. The user may choose between WIA(1^+), WIA(2^+), and WIA(3^+). WIA(1^+) will typically result in individuals being declared casualties and then reporting to the medical system sooner than would WIA(2^+) or WIA(3^+) (see Figure 1-1). Methodologically, reporting to the medical system for injuries of lower severity results in fewer deaths and more personnel in the medical system (individuals are less likely to die before reaching an MTF). The default value is WIA(1^+).

1.6.2. CHALLENGE

1. If the user provided the CBRN Challenge per icon over time, the methodology uses those values and the icon attributes to estimate the Effective CBRN Challenge.

2. If the user provided the Effective CBRN Challenge per icon, the values are not modified.

1.6.3. RESPONSE and STATUS

1. The RESPONSE and STATUS steps are intertwined; much of this document discusses them together. Chapter 4 discusses them for CRN challenges, and Chapter 5 discusses them for biological challenges.

2. The human response model uses the Effective CBRN Challenge and the values of $Flag_{MT}$, $T_{death\text{-}CN\text{-}SL4}$, and T_{MTF} to estimate the distribution of Injury Severity Levels and deaths in the PAR over time. Although there are general CRN, non-contagious biological, and contagious biological *frameworks*, the human response

[34] Or *not yet treated* casualty en route to a MTF

models vary widely among different challenge types, even within the same framework. Thus, the human response model used is specific to the challenge.

3. Based on the output of the human response model, the value of T_{MTF}, and the casualty criterion, the methodology estimates the distribution of casualties in the PAR over time.

a. Figure 1-1 depicts how the casualty criterion and an individual's Injury Severity Level are used to determine whether the individual becomes WIA. The *time* at which the individual becomes a casualty depends on the human response model, which dictates when the individual's Injury Severity Level changes.

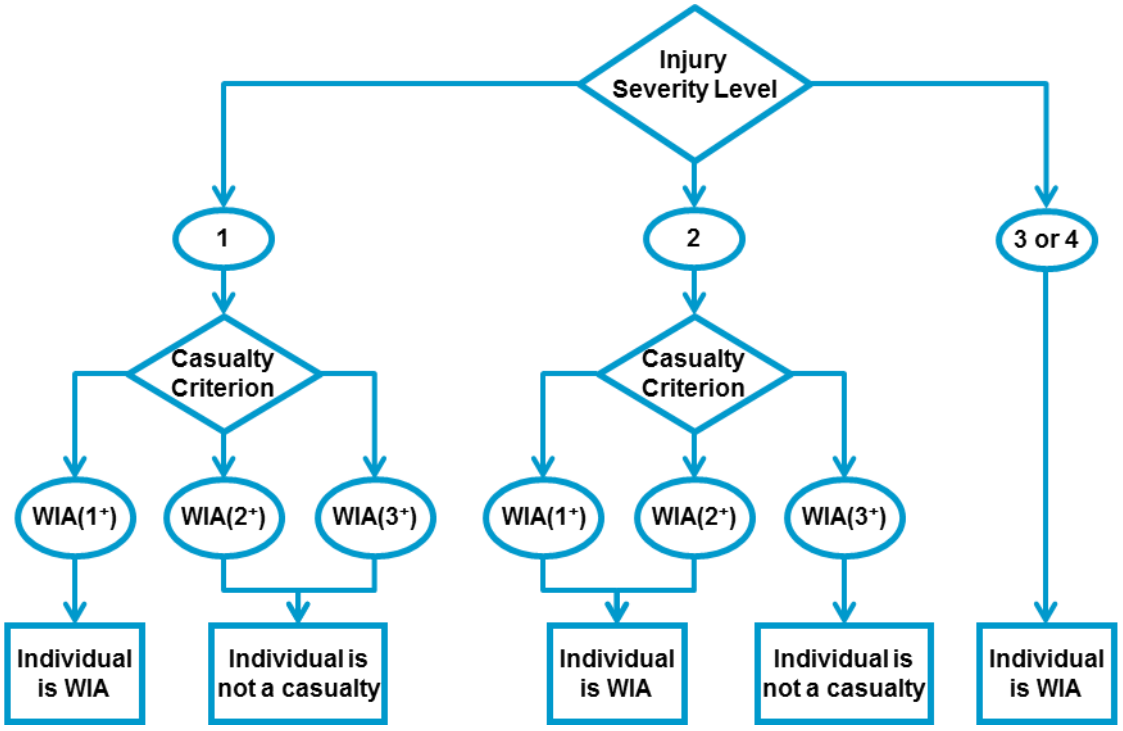


Figure 1-1: Relationship of Casualty Criterion, Severity Level, and WIA

b. Figure 1-2 shows the process for assigning casualty category as a function of time for any individual. In general, an individual becomes a casualty when his Injury Severity Level first meets or exceeds the casualty criterion (WIA). All other casualty categories are assigned after an individual is first declared WIA according to Figure 1-1.

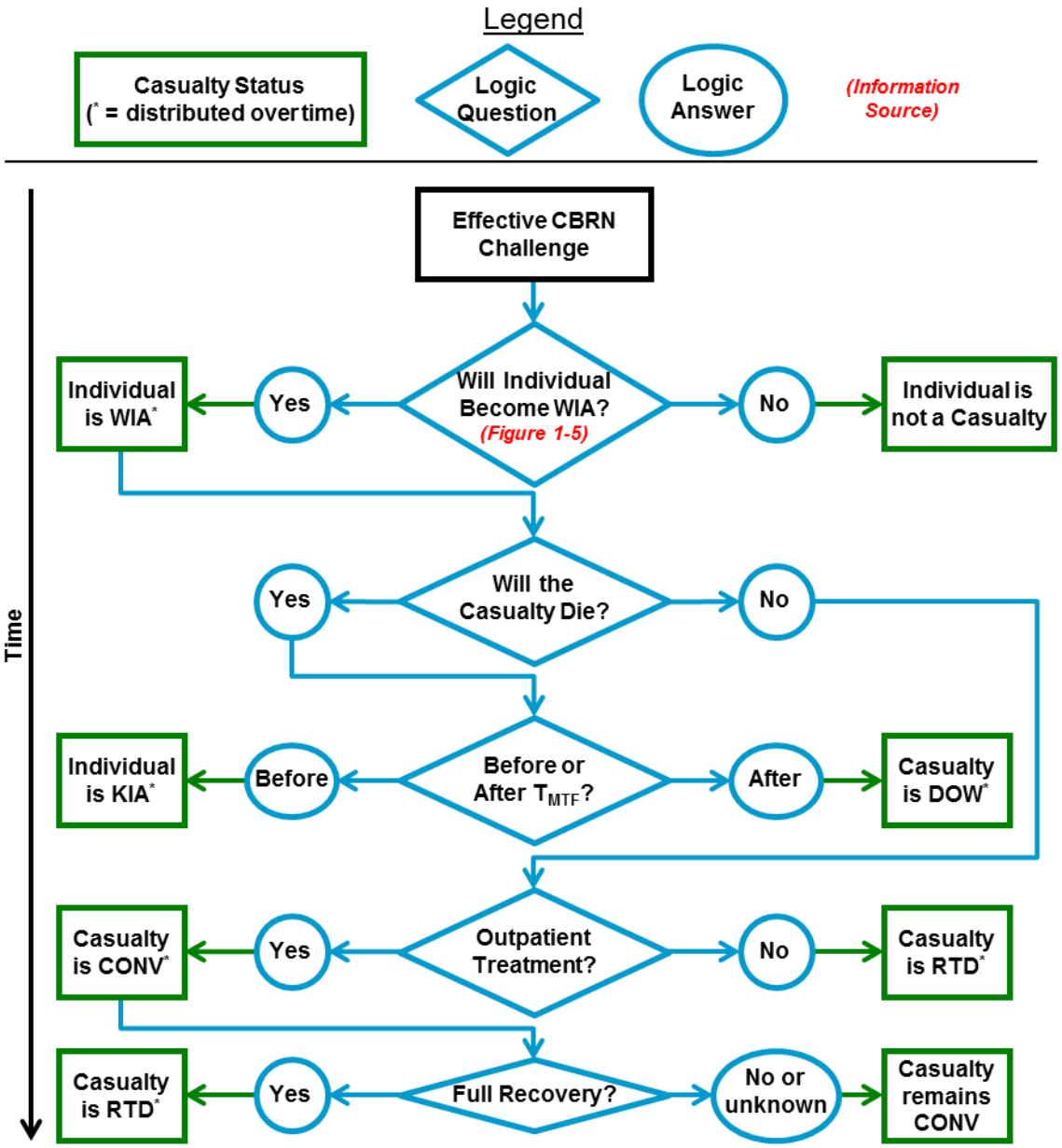


Figure 1-2: Decision Tree for Assignment of Casualty Category

4. The methodology cannot account for the combined effects of multiple biological challenges or of a biological challenge and a CRN challenge. However, it does have a limited capability to account for multiple CRN challenges using Composite Injury Profiles; a user may generate Composite Injury Profiles as needed using Figure 4-1.

1.6.4. REPORT

1. Per guidance from AJP-4.10, the four outputs are labeled PAR, rates, profile, and flow. These provide an estimate of how many casualties occur, when they occur, the types of injury, and when changes in casualty category are expected to occur.

   a. The PAR is simply the total number of personnel included in the scenario—a user input.

   b. The rate has two components: the number of new casualties in each category per 100 of the PAR per day, and the total number of new casualties in each category per day. These are reported in tables.

   c. The flow characterizes the movement between casualty categories.[35] The casualty flow is presented within the rate tables.

   d. The profile is a description of the relative proportions of types of injuries. Some example injury types in the context of this document are “WIA—mild rad”, “CONV—GB”, and “KIA—C” (where C indicates “chemical”). The casualty profile is presented within the rate tables.

2. Reports are generated with a time resolution of one day. This time resolution is fixed.

3. Since it is possible for an individual to be assigned to multiple casualty categories within a *single* day, the rules below are followed to facilitate more appropriate resource planning and to avoid double-counting.

   a. An individual who is WIA and then KIA is reported as KIA.

   b. An individual who is WIA and then DOW is reported as WIA.

   c. An individual who is WIA and then CONV or RTD is reported as WIA.

   d. An individual who is CONV and then RTD is reported as CONV.

   e. On following day, the casualty’s chronologically *later* status is reported. Thus, a WIA—KIA is reported as KIA on the following day, a WIA—DOW/CONV/RTD is reported as DOW/CONV/RTD on the following day, and a CONV—RTD is reported as RTD on the following day.

[35] AJP-4.10 also describes flow as characterizing how the timing of casualties depends on when incidents occur, which is beyond the purview of this document.

5. Reporting continues until no further changes in casualty category occur.

1.6.5. User Aids

1. Figure 1-3 provides a methodology overview.

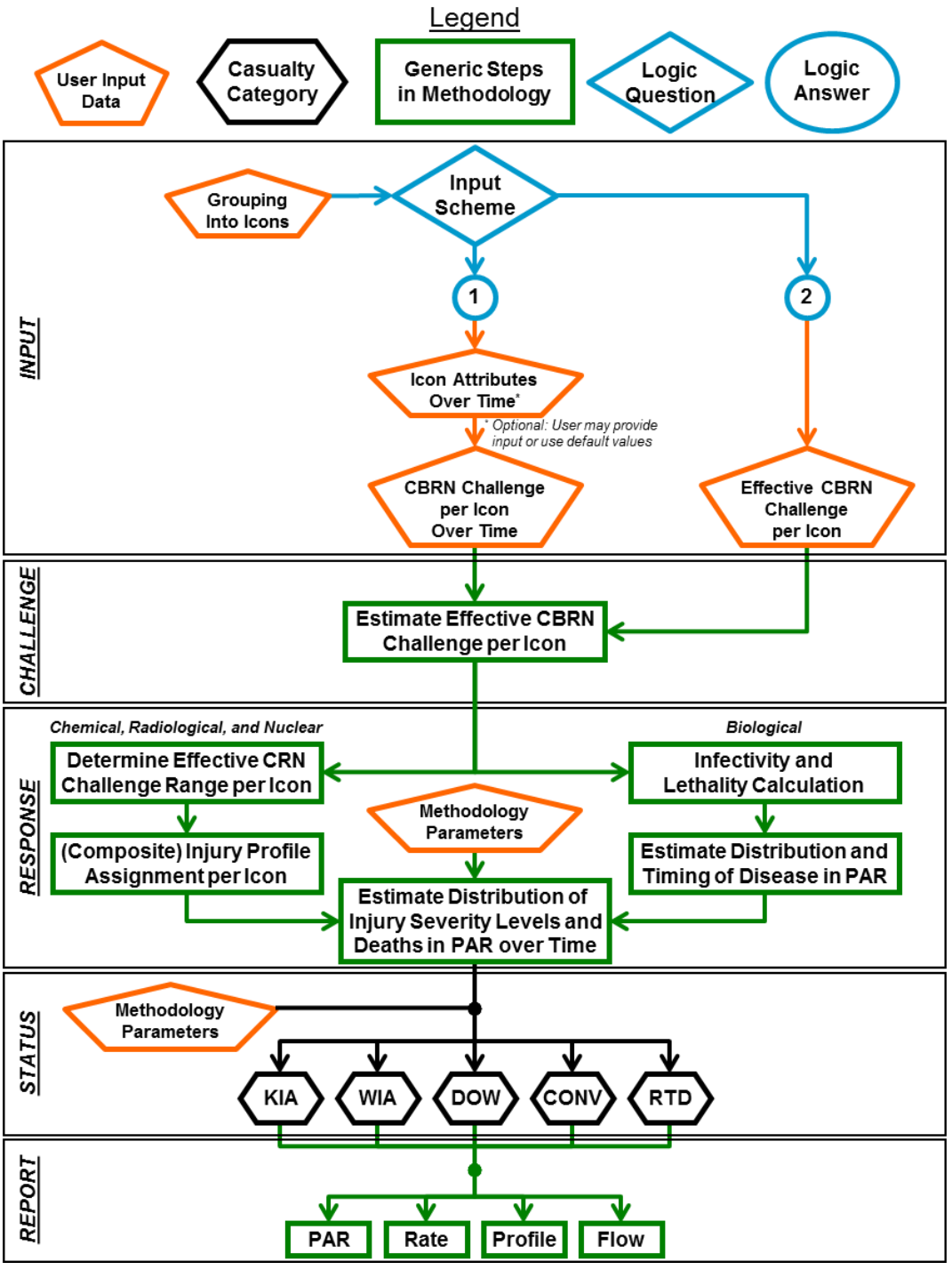


Figure 1-3: AMedP-7.5(A) Methodology Overview

2. Table 1-4 is a roadmap for the user. For each challenge type, it specifies the section of this document to be used to complete each of the five steps described above.

Table 1-4: User's Roadmap

Agent, Effect, or Disease	INPUT	CHALLENGE	RESPONSE/STATUS	REPORT
Chemical				
GB	Ch. 2	Ch. 3	Sections 4.2.2 and 4.1	Ch. 6
VX	Ch. 2	Ch. 3	Section 4.2.3 and 4.1	Ch. 6
HD	Ch. 2	Ch.3 and Section 4.2.4.2.	Section 4.2.4 and 4.1	Ch. 6
CG	Ch. 2	Ch. 3	Section 4.2.5 and 4.1	Ch. 6
Cl_2	Ch. 2	Ch. 3	Section 4.2.6 and 4.1	Ch. 6
AC	Ch. 2	Ch. 3	Section 4.2.7 and 4.1	Ch. 6
CK	Ch. 2	Ch. 3	Section 4.2.8 and 4.1	Ch. 6
H_2S	Ch. 2	Ch. 3	Section 4.2.9 and 4.1	Ch. 6
Radiological				
RDD	Ch. 2	Ch. 3 and Section 4.3.2.2	Section 4.3.3 and 4.1	Ch. 6
Fallout	Ch. 2	Ch. 3 and Section 4.3.3.2	Section 4.3.4 and 4.1	Ch. 6
Nuclear				
Initial Whole-Body Radiation	Ch. 2	Ch. 3 and Section 4.4.2.2	Section 4.4.2 and 4.1	Ch. 6
Blast	Ch. 2	Ch. 3	Section 4.4.3 and 4.1	Ch. 6
Thermal Fluence	Ch. 2	Section 4.4.4.2	Section 4.4.4 and 4.1	Ch. 6
Combined Nuclear Effects	N/A	N/A	Section 4.4.5	Ch. 6
Biological				
Anthrax	Ch. 2	Ch. 3	Section 5.2.1 and 5.1.3	Ch. 6
Brucellosis	Ch. 2	Ch. 3	Section 5.2.2 and 5.1.3	Ch. 6
Glanders	Ch. 2	Ch. 3	Section 5.2.3 and 5.1.3	Ch. 6
Melioidosis	Ch. 2	Ch. 3	Section 5.2.4 and 5.1.3	Ch. 6
Plague (non-contagious)	Ch. 2	Ch. 3	Section 5.2.5 and 5.1.3	Ch. 6
Plague (contagious)	Ch. 2	Ch. 3	Section 5.2.6 and 5.1.4	Ch. 6
Q Fever	Ch. 2	Ch. 3	Section 5.2.7 and 5.1.3	Ch. 6
Tularemia	Ch. 2	Ch. 3	Section 5.2.8 and 5.1.3	Ch. 6
Smallpox (non-contagious)	Ch. 2	Ch. 3	Section 5.2.9 and 5.1.3	Ch. 6
Smallpox (contagious)	Ch. 2	Ch. 3	Section 5.2.10 and 5.1.4	Ch. 6
EVD/MVD (non-contagious)	Ch. 2	Ch. 3	Section 5.2.11 and 5.1.3	Ch. 6
EVD/MVD (contagious)	Ch. 2	Ch. 3	Section 5.2.12 and 5.1.4	Ch. 6
EEE	Ch. 2	Ch. 3	Section 5.2.13 and 5.1.3	Ch. 6
VEE	Ch. 2	Ch. 3	Section 5.2.14 and 5.1.3	Ch. 6
WEE	Ch. 2	Ch. 3	Section 5.2.15 and 5.1.3	Ch. 6
Botulism	Ch. 2	Ch. 3	Section 5.2.16 and 5.1.3	Ch. 6
Ricin	Ch. 2	Ch. 3	Section 5.2.17 and 5.1.3	Ch. 6
SEB	Ch. 2	Ch. 3	Section 5.2.18 and 5.1.3	Ch. 6
T-2 Mycotoxin	Ch. 2	Ch. 3	Section 5.2.19 and 5.1.3	Ch. 6

CHAPTER 2 USER INPUT

This chapter fully describes each required and optional user input—it discusses the INPUT step of the methodology. It includes example input tables, default parameter values, and guidance to the user.

2.1. ICONS AND ICON ATTRIBUTES

1. An icon is a group of individuals sharing a common location over time. For example, four people in a tank or a grouping of personnel in fighting positions. Each icon is given a unique numerical identifier, called the icon index.

2. When defining icons, the user must determine the appropriate way to group individuals. For example, a cluster of individuals within a 10 km^2 area may be represented by a single icon or by multiple icons. When considering scenarios covering several hundred square kilometers in area, users may wish to choose a lower spatial resolution—where each icon covers a larger geographic area—than when considering scenarios covering only a few square kilometers.

3. The user's grouping of individuals into icons is external to the methodology. The input required by the methodology is described below in terms of icon attributes.

2.1.1. Overview of Icon Attributes

1. The user must provide the number of personnel in each icon.

2. The user may provide identifying information to assist in interpreting results, such as battalion, company, platoon, and area. This information is not used by the methodology.

3. The user must provide CBRN Challenge data (Input Scheme 1) or the Effective CBRN Challenge (Input Scheme 2). These inputs must be derived from a hazard prediction model.

4. If the user provided CBRN Challenge (Input Scheme 1), then it is strongly recommended that the user also define challenge-modifying attributes to match the planning scenario; otherwise, default values will be used. Table 2-1 summarizes the attributes and identifies which attributes are considered when estimating an icon's Effective CBRN Challenge, as a function of the challenge type. The values of challenge-modifying icon attributes may change over time, as specified by the user.

Table 2-1: Challenge-Modifying Icon Attributes

Challenge Type	Attributes and Potential Methodological Relevance					
	Breathing Rate	Body Surface Area	IPE	Vehicle or Shelter*	Pre-exposure Prophylaxis	Uniform
Chemical inhalation	X		X	X	X	
Chemical perc. vapor			X	X	X	
Chemical perc. liquid		X	X	X	X	
Biological inhaled	X		X	X		
Gamma radiation				X		
Neutron radiation				X		
Beta radiation			X	X		
Blast shielding				X		
Thermal shielding				X		X

* Relates to physical protection and ColPro.

5. If the user provided the Effective CBRN Challenge (Input Scheme 2), then the methodology will not use the challenge-modifying attributes.

6. The use of icons and icon attributes supports several important features.

   a. Using icons supports the application of spatially-resolved output from hazard prediction models, despite the fact that icon location is not an input for this methodology.

   b. Using icon attributes allows the user to account for a postulated distribution of defensive postures across the PAR.

   c. The ability to change the values of icon attributes over time allows the user to account for warning and response, which is the combined process of gathering information indicating that a CBRN incident has occurred, assessing that information to determine its meaning and implications, and deciding upon an appropriate tactical response. Example tactical responses the icon attributes might account for are:

      1) A command decision that all personnel must wear certain IPE because of the assessed threat.

      2) Donning IPE or taking shelter in response to observing nerve agent poisoning symptoms in some personnel.

      3) Donning IPE or taking shelter in response to a detector alarm.

2.1.2. CBRN Challenge or Effective CBRN Challenge

1. The user may supply CBRN challenge information according to one of two input schemes (summarized in the INPUT box in Figure 1-3). The choice of input scheme should be determined by whether the user is able to provide input for the

challenge-modifying icon attributes. As more input is provide, the resulting casualty estimate will better match the planning scenario.

2. CBRN Challenge (Input Scheme 1).

   a. The user must provide data for each icon at each time point. Note, however, that a user may choose only one time point (at the end of the challenge).

   b. The final time point should be the time past which the CBRN Challenge no longer increases—that is, the provided input should encompass the entire period over which icons are challenged.

   c. Time must be specified in units of minutes. The total duration, number of time points, and intervals between time points are user-specified. A varying time interval is allowed, but the time intervals must be the same all icons.

   d. The user should ensure that the hazard prediction model used to generate the challenge data has time resolution sufficient to capture the fidelity of icon movement[36] and defensive action the user desires to model. For example, if the user wishes to capture the ability of individuals to don a mask in 15 seconds, the time interval around the time when individuals don masks must be 15 seconds or shorter. If icons are not moving or taking any defensive actions, a time interval of up to 5 minutes is acceptable.

   e. The data must be cumulative, not instantaneous. Cumulative relates to the area under the curve of a plot of challenge versus time, whereas instantaneous relates to the specific magnitude of the challenge at a given time. If the user's hazard prediction model only outputs instantaneous data, the user must use a numerical integration technique[37] to generate the cumulative input data required by the methodology.

3. Effective CBRN Challenge (Input Scheme 2).

   a. The user must provide a single value for each icon.

   b. The methodology will not modify the user-provided values. Thus, the user must already have accounted for the challenge-modifying icon attributes.

4. The input must be provided in the units specified in Table 2-2. If Input Scheme 1 is used, the methodology will calculate the Effective CBRN Challenge in the

[36] Note that although the methodology does not use icon locations, icon movement could be reflected by changes in the values of challenge-modifying icon attributes.

[37] For example, Simpson's rule (see http://en.wikipedia.org/wiki/Simpson%27s_rule).

appropriate units.

Table 2-2: Challenge Types and Associated Units for CBRN Challenges

Agent or Effect Challenge Type (Subcomponents, if any)	Symbol (Q)	CBRN Challenge (Input Scheme 1)	Effective CBRN Challenge (Input Scheme 2)
GB			
Inhaled GB Vapor	GB,ih	mg-min/m^3	mg-min/m^3
VX			
Inhaled VX Vapor	VX,ih	mg-min/m^3	mg-min/m^3
Percutaneous VX Liquid	VX,pc	mg-min/m^3	mg
HD			
Inhaled HD Vapor	HD,ih	mg-min/m^3	mg-min/m^3
Ocular HD Vapor	HD,oc		mg-min/m^3
(Percutaneous Vapor)	HD,pv	mg-min/m^3	
Equivalent Percutaneous HD Vapor	HD,epc		mg-min/m^3
(Percutaneous Vapor)	HD,pv	mg-min/m^3	
(Percutaneous Liquid)	HD,pl	mg	
CG			
Inhaled CG Vapor	CG,ih	mg-min/m^3	mg-min/m^3
Peak Inhaled CG Concentration	CG,[ih]	mg/m^3	mg/m^3
Cl_2			
Inhaled Cl_2 Vapor	Cl2,ih	mg-min/m^3	mg-min/m^3
AC			
Inhaled AC Vapor	AC,ih	mg-min/m^3	mg-min/m^3
CK			
Inhaled CK Vapor	CK,ih	mg-min/m^3	mg-min/m^3
Peak Inhaled CK Concentration	CK,[ih]	mg/m^3	mg/m^3
H_2S			
Inhaled H_2S Vapor	H2S,ih	mg-min/m^3	mg-min/m^3
RDD			
Cutaneous Radiation	RDD,cut		Gy
(Skin Contamination)	RDD,cut,s	kBq/m^2	
(Cloudshine)	RDD,cut,cld	kBq-hr/m^3	
(Groundshine)	RDD,cut,grd	kBq-hr/m^2	
Whole-Body Radiation	RDD,wb		Gy
(Cloudshine)	RDD,wb,cld	kBq-hr/m^3	
(Groundshine)	RDD,wb,grd	kBq-hr/m^2	
Fallout			
Cutaneous Radiation	FO,cut		Gy
(Skin Contamination)	FO,cut,s	kBq-hr/m^2	
(Groundshine Gamma)	FO,cut,grd-γ	Gy	
(Groundshine Beta)	FO,cut,grd-β	Gy	
Whole-Body Radiation	FO,wb		Gy
(Groundshine)	FO,wb,grd	Gy	

Nuclear Detonation Whole-Body Radiation (Neutron) (Gamma) Blast Static Overpressure Thermal Fluence	 nuc,wb nuc,wb,n^0 nuc,wb,γ nuc,blast nuc,thermal	 Gy Gy kPa kJ/m^2	 Gy kPa %BSA
Anthrax Inhaled *B. anthracis*	anthrax	spore-min/m^3	spore
Brucellosis Inhaled *Brucella*	brucellosis	CFU*-min/m^3	CFU*
Glanders Inhaled *B. mallei*	glanders	CFU*-min/m^3	CFU*
Melioidosis Inhaled *B. pseudomallei*	melioidosis	CFU*-min/m^3	CFU*
Plague Inhaled *Y. pestis*	plague	CFU*-min/m^3	CFU*
Q fever Inhaled *C. burnetii*	Q fever	organism-min/m^3	organism
Tularemia Inhaled *F. tularensis*	tularemia	organism-min/m^3	organism
Smallpox Inhaled *V. major*	smallpox	PFU†-min/m^3	PFU†
Ebola Virus Disease (EVD) Inhaled Ebola virus	ebola	PFU†-min/m^3	PFU†
Marburg Virus Disease (MVD) Inhaled Marburg virus	marburg	PFU†-min/m^3	PFU†
Eastern Equine Encephalitis (EEE) Inhaled EEE virus	EEE	PFU†-min/m^3	PFU†
Venezuelan Equine Encephalitis (VEE) Inhaled VEE virus	VEE	PFU†-min/m^3	PFU†
Western Equine Encephalitis (WEE) Inhaled WEE virus	WEE	PFU†-min/m^3	PFU†
Botulism Inhaled Botulinum neurotoxin	botNT	µg-min/m^3	µg
Ricin Inhaled Ricin	ricin	µg-min/m^3	µg
Staphylococcal enterotoxin B (SEB) Inhaled SEB	SEB	µg-min/m^3	µg
T-2 Mycotoxin Inhaled T-2 Mycotoxin	T-2	mg-min/m^3	mg

* CFU = Colony Forming Unit; relation between organisms and CFU is agent-dependent.

† PFU = Plaque Forming Unit; relation between organisms and PFU is agent-dependent.

2.1.3. Breathing Rate

1. For inhaled chemical and biological agent challenges, the breathing rate is used in the calculation of the inhaled[38] concentration time (chemical) or inhaled dose (biological).

2. The user may specify either the qualitative level of activity—which will be converted to a breathing rate according to Table 2-3—or a specific breathing rate in units of m^3/min. If no input is provided, the default values in Table 2-3 will be used.

3. The chemical agent human response models have a built-in assumption of a 0.015 m^3/min (15L/min) breathing rate. Thus, breathing rate is not used directly; a unitless factor defined as the breathing rate divided by 0.015 m^3/min is used.

4. The biological agent human response models *do not* have a built-in breathing rate assumption, so breathing rate in units of m^3/min is used.

5. Table 2-3 specifies the default and suggested alternate values for the breathing rate. The user may specify any desired breathing rate.

Table 2-3: Suggested and Default Breathing Rates

	Optional Input—user need specify only one, or may use defaults		
Challenge Type	**Activity Level**	**Breathing Rate [m^3/min*]†**	**Unitless Factor§**
Chemical Agent Inhalation	At Rest	0.0075	0.5
	Light (*default*)	0.0150 (*default*)	1 (*default*)
	Moderate	0.0300	2
	Heavy	0.0750	5
Biological Agent Inhalation	At Rest	0.0075	N/A
	Light (*default*)	0.0150 (*default*)	N/A
	Moderate	0.0300	N/A
	Heavy	0.0750	N/A

* Multiply breathing rate in m^3/min by 1,000 to convert to L/min.
† David W. Layton, "Metabolically Consistent Breathing Rates for Use in Dose Assessments," *Health Physics* 64, no. 1 (1993): 23–36.
§ The unitless factor is calculated by dividing the actual breathing rate by 0.015 m^3/min.

2.1.4. Body Surface Area

1. For liquid chemical agent challenges, the total body surface area challenged is used in the calculation of the dose.

[38] The fraction of inhaled agent that is retained is irrelevant because the underlying models are based on the amount of inhaled agent

2. The standard man is typically assumed to have 1.8 m^2 of body surface area. Since most hazard prediction models do not have the fidelity to determine the orientation of personnel relative to the challenge, the default and recommended value is 1 m^2, representing about half of a person's body surface area.

3. Users may provide a different value, but must be careful not to change the body surface area in an attempt to account for clothing or IPE; other icon attributes accounts for those effects.

2.1.5. IPE

1. IPE may provide protection against chemical and biological inhalation, chemical vapor and liquid percutaneous, and beta radiation challenges.

2. These protective effects are modeled using pre-determined protection factors. See Table 2-6 for suggested values. The symbol used in this document for protection factors from IPE follows the format $PF_{IPE,Q,n}$, where Q is the challenge type.

3. IPE, clothing, and even regular combat uniforms may also provide some protection against thermal challenges, but these protective effects are incorporated into the thermal fluence thresholds listed in Table 4-48 (section 4.4.4), so protection factors are not used.

Table 2-4: Suggested IPE Protection Factors

Optional Input

Item		Protection Factors*			
Class	Example	Inhalation ($PF_{IPE,ih,n}$)	Perc. Vapor ($PF_{IPE,pv,n}$)	Perc. Liquid ($PF_{IPE,pl,n}$)	Beta Radiation† ($PF_{IPE,\beta,n}$)
None	Standard combat uniform	1	1	1	1
Mask	M40, M50	1667	1	1	1
Suit	Hands, face, neck exposed (MOPP II)	1	9	9	1
	Covering entire body (MOPP IV)	1	∞	∞§	∞

* The values in these columns are notional—users are encouraged to use national values based on operational test data, as available.

† In this methodology, beta radiation can come from fallout or an RDD containing ^{90}Sr.

§ Such equipment is typically designed for a 10 g/m^2 challenge. Although the protection is not truly infinite, a protection factor of ∞ may be used for all practical purposes.

2.1.6. Vehicles and Shelters (Physical Protection and ColPro)

1. Vehicles and shelters may provide protection against all challenge types. The degree of protection provided generally depends on the type of shelter or vehicle.

2. These protective effects are modeled using protection factors for all

challenges but thermal fluence. See Table 2-6 through Table 2-8 for suggested values. The symbol used in this document for protection factors from vehicles and shelters follows the format $PF_{V\text{-}SH,Q,n}$, where Q is the challenge type.

a. Vehicles and shelters are assumed to completely protect icons from liquid chemical agent challenges.

b. Inhalation and percutaneous vapor protection afforded by vehicles and shelters *with* ColPro is modeled using pre-determined protection factors.

c. Inhalation and percutaneous vapor protection afforded by vehicles and shelters *without* ColPro is modeled protection factors that must be estimated on a per-icon and per-challenge basis using Equation 2-1, which depends the air exchange rate, the duration of occupancy, and the duration the vehicle or shelter is enveloped in the cloud.[39]

$$PF_{V\text{-}SH,ih/pv,n} = \frac{AER_n \cdot Duration_n}{AER_n \cdot Duration_n + e^{(-AER_n \cdot Occupancy_n)} - e^{AER_n \cdot (Duration_n - Occupancy_n)}}, \quad (2\text{-}1)$$

where:

$PF_{V\text{-}SH,ih/pv,n}$ is the protection factor for icon *n* for the duration of $Occupancy_n$,

AER_n is the air exchange rate at icon *n* [air changes per hour (ACH)]—Table 2-5 provides suggested air exchange rates for various vehicles and shelters,

$Duration_n$ is the length of time the cloud envelopes the vehicle/structure while it is occupied by icon *n* [hr], and

$Occupancy_n$ is the length of time of vehicle/structure occupancy from the time of cloud arrival at icon *n* [hr], which must be greater than or equal to $Duration_n$.

Note for Input Scheme 1: if an icon leaves the vehicle or shelter while it is still enveloped, $Duration_n$ and $Occupancy_n$ must be set equal to avoid negative numbers. Accordingly, the resulting protection factor must only be applied to the time steps during

[39] William K. Blewett et al., *Expedient Sheltering in Place: An Evaluation for the Chemical Stockpile Emergency Preparedness Program* (Aberdeen Proving Ground, MD: Edgewood Research Development and Engineering Center, June 1996), 14–20.

which the icon occupied the vehicle or shelter.

Table 2-5: Suggested Air Exchange Rates for Vehicles and Shelters

Vehicle/Shelter Class	Examples	Air Exchange Rate (AER_n)* [ACH]
Residential Building – Closed Windows	Barracks	0.5
Nonresidential Building – Closed Windows	Administrative, Control and Work Buildings	1.25
Residential Building – Open Windows	Hangar	6
Stationary Vehicle – Open Windows, No Ventilation	CBPS, Tent†, TOC	13.3
Stationary Vehicle – Closed Windows, Fan on Recirculation	155 mm SP, 5-ton Van, Recovery	20
Moving Vehicle – Closed Windows	4.2 MTR, ACE, CHAPP, M106 A2 4.2, M113	36
Stationary Vehicle – Open Windows, Fan on Fresh Air	Truck/Van	40

* Adapted from J. H. Park et al., "Measurement of Air Exchange Rate of Stationary Vehicles and Estimation of in-Vehicle Exposure," *Journal of Exposure Analysis and Environmental Epidemiology* 8, no. 1 (1998): 65–78 and Ted Johnson, *A Guide to Selected Algorithms, Distributions, and Databases Used in Exposure Models Developed by the Office of Air Quality Planning and Standards* (Chapel Hill, NC: TRJ Environmental, Inc., 2002).

† Tents are assumed to have an ACH of 13.3, the same as a stationary vehicle with windows open and no ventilation.

Table 2-6: Suggested Inhalation and Percutaneous Protection Factors for Vehicles and Shelters

Optional Input				
Vehicle or Shelter	Example	Protection Factors*		
		Inhalation ($PF_{V\text{-}SH,ih,n}$)	Perc. Vapor ($PF_{V\text{-}SH,pv,n}$)	Perc. Liquid ($PF_{V\text{-}SH,pl,n}$)
None	Dismounted, Foxhole	1	1	1
Vehicle w/ColPro	155 mm SP, Recovery, ACE, M106 A2 4.2, M113, TOC, CBPS	3000	3000	∞
Vehicle w/o ColPro	4.2 MTR, CHAPP, 5-ton Van, Tent, Truck/Van	Use Equation 2-1		∞
Building w/ColPro	Admin Building, Control Building, ColPro Barracks	3000	3000	∞
Building w/o ColPro	Barracks, Hangar, Work Building	Use Equation 2-1		∞

* The values in these column are notional—users are encouraged to use national values based on operational test data, as available.

d. Radiation and blast shielding afforded by vehicles and shelters are modeled using pre-determined protection factors. Suggested protection factors are listed in Table 2-7 and Table 2-8. Note that the level of protection each vehicle or shelter provides is typically different for neutron and gamma radiation. Further, all vehicles and shelters are assumed to provide complete

protection from beta radiation, so the suggested protection factor is ∞.

Table 2-7: Suggested Radiation Shielding Protection Factors for Vehicles and Shelters

Optional Input			
Vehicle or Shelter	**Protection Factors***		
	Neutron Radiation† ($PF_{V\text{-}SH,n^0,n}$)	**Gamma Radiation† ($PF_{V\text{-}SH,\gamma,n}$)**	**Beta Radiation† ($PF_{V\text{-}SH,\beta,n}$)**
Armored Personnel Carrier	1.22	2.70	∞
Earth Shelter	16.67	66.67	∞
Exposed/Dismounted	1.00	1.00	∞
Foxhole	3.03	10.00	∞
Masonry Building	8.33	6.67	∞
Multi-Story Brick Building	1.33	1.56	∞
Tank	3.57	10.00	∞
Tent	1.00	1.00	∞
Truck	1.00	1.25	∞
Van	1.05	1.05	∞
Wood Frame Building	1.39	1.22	∞

* The values in this table are notional—users are encouraged to use other values based on operational test data, as available.

† In this methodology, the only source of neutron radiation is a prompt radiation from a nuclear detonation. Gamma radiation can come from RDDs (all isotopes listed in Table 3-1 except ^{90}Sr are primarily gamma emitters), fallout, and prompt radiation from nuclear detonations. Beta radiation can come from fallout or ^{90}Sr, the only primary beta emitter in Table 3-1.

Table 2-8: Suggested Blast Shielding Protection Factors

	Optional Input
Vehicle/Shelter Blast Class	**Blast Shielding Protection Factor* ($PF_{V\text{-}SH,blast,n}$)**
All	1

* No generally accepted blast shielding protection factors were available; this table is a placeholder. Users may input specific national data, if desired.

3. The protection vehicles and shelters provide from thermal fluence is not modeled using protection factors because the equation used to estimate thermal insults is not applicable to partially protected bodies. For details on how it is included in the human response estimates, see section 4.4.4.

2.1.7. Pre-Exposure Prophylaxis

1. In general, pre-exposure prophylaxis might provide protection against any challenge type.

2. No currently fielded prophylaxis options are modeled using protection factors, so Table 2-9 is a placeholder to help illustrate how the methodology would incorporate prophylaxis, pending future development of relevant prophylaxis. The

symbol used in this document for protection factors from pre-exposure prophylaxis follows the format $PF_{proph,Q,n}$, where Q is the challenge type.

Table 2-9: Suggested Protection Factors for CRN Prophylaxis

	Optional Input	
Specific Prophylaxis	**Challenge Type(s) For Which the Prophylaxis is Effective**	**Prophylaxis Protection Factor* ($PF_{proph,Q,n}$)**
None	All	1

* No relevant prophylaxis is currently fielded; this table is a placeholder for future capabilities. Users may input specific national data, if desired.

3. Note that although vaccination and/or chemoprophylaxis are available for many biological agents, the protective effects are not modeled using a protection factor—see section 5.2 for details on how each biological agent prophylaxis option is used in the human response estimate.

2.1.8. Uniform

Uniforms may provide some protection against thermal challenges, but these protective effects are incorporated into the thermal fluence thresholds listed in Table 4-48 (section 4.4.4), so protection factors are not used.

2.1.9. Aggregate Protection Factor

1. The protection factors associated with the IPE, vehicle or shelter, and pre-exposure prophylaxis attributes are used in Equation 2-2 to calculate an icon's Aggregate Protection Factor (APF), which is used in the equations in Chapter 3 during the calculation of an icon's Effective CBRN Challenge.

$$APF_{Q,n} = PF_{IPE,Q,n} \cdot PF_{V\text{-}SH,Q,n} \cdot PF_{proph,Q,n}, \qquad (2\text{-}2)$$

where:

$APF_{Q,n}$ is icon *n*'s APF for challenge type Q,

$PF_{IPE,Q,n}$ is the protection factor for challenge type Q from all IPE used by icon *n*,

$PF_{V\text{-}SH,Q,n}$ is the protection factor for challenge type Q from the vehicle or shelter occupied by icon *n* (accounts for physical protection and ColPro), and

$PF_{proph,Q,n}$ is the protection factor for challenge type Q from any pre-exposure prophylaxis used by icon *n*.

2. If the user does not provide input for a particular protection factor, the default value of 1 is used. Thus, if the user provides no input for any protection factor, the APF = 1—no protection is modeled.

2.1.10. Example Input and Comparison of Input Schemes

1. Table 2-10 is an example of icon definitions including identifying information.

Table 2-10: Example Definition of Icons

Required Input		Optional Input			
Icon Index	**# of Individuals**	**Battalion**	**Company**	**Platoon**	**Area**
1	4	Abn Inf Bn (+)	1-A Rifle Co	1-A-HQ	1-A Co Area
2	4	Abn Inf Bn (+)	1-B Rifle Co	1-B-HQ	1-B Co Area
3	1	Abn Inf Bn (+)	HHC		1 Bn HQ
4	4	Abn Inf Bn (+)	1-C Rifle Co	1-C-HQ	1-C Co Area
5	1	Abn Inf Bn (+)	HHC		1 Bn HQ
6	7	Abn Inf Bn (+)	1-A Rifle Co	1-A-1-1	1-A Co Area

2. Table 2-11 is an example of Input Scheme 1 input for the first five icons from Table 2-10, for a notional GB incident. Data for the CBRN Challenge and various icon attributes are listed.

3. Table 2-11 shows that after the incident begins, icons 1, 2, and 4 don masks, and icons 1 and 4 also change activity levels; protection factors and breathing rates change accordingly. Input Scheme 1 is able to capture those changes.

4. A user modeling the same scenario using both Input Scheme 2 would be forced to answer the following regarding the input to provide for icons 1, 2, and 4.

a. Should icons 1, 2, and 4 be modeled as having the protection factor associated with masks, or not?

b. Which breathing rate should be used for icons 1 and 4?

5. Table 2-12 is example of Input Scheme 2 input for the same five icons and notional GB incident, based on the following answers to the questions posed above.

a. Icon 1 should be modeled with 0.015 m^3/min, and icon 4 should be modeled with 0.030 m^3/min.

b. Choice 1: icons 1, 2, and 4 should be modeled using the mask protection factor.

c. Choice 2: icons 1, 2, and 4 should *not* be modeled using the mask protection factor.

Table 2-11: Example Input for Input Scheme 1, for a Notional GB Incident

Required Input			Optional Input			
Icon Index	Time (min)	Concentration-time (mg-min/m^3)	Activity Level*	IPE Class†	Vehicle or Shelter Class†	Prophylaxis†
1	0	0	At Rest	None	None	None
1	1	15.0	Moderate	Mask	None	None
1	4	38.4	Light	Mask	None	None
1	8	52.0	Light	Mask	None	None
1	10	55.0	Light	Mask	None	None
2	0	0	Light	None	None	None
2	1	60.2	Light	Mask	None	None
2	4	192.8	Light	Mask	None	None
2	8	312.0	Light	Mask	None	None
2	10	345.4	Light	Mask	None	None
3	0	0	At Rest	None	Building w/ColPro	None
3	1	0	At Rest	None	Building w/ColPro	None
3	4	0	At Rest	None	Building w/ColPro	None
3	8	0	At Rest	None	Building w/ColPro	None
3	10	0	At Rest	None	Building w/ColPro	None
4	0	0	At Rest	None	None	None
4	1	18.8	Moderate	None	None	None
4	4	23.8	Heavy	Mask	None	None
4	8	23.8	Heavy	Mask	None	None
4	10	23.8	Heavy	Mask	None	None
5	0	0	At Rest	None	Building w/ColPro	None
5	1	0	At Rest	None	Building w/ColPro	None
5	4	7.8	At Rest	None	Building w/ColPro	None
5	8	35.0	At Rest	None	Building w/ColPro	None
5	10	42.8	At Rest	None	Building w/ColPro	None

* Instead of activity level, a user could provide a specific breathing rate—see Table 2-3.

† Instead of these general descriptors, a user could provide a specific protection factor for each icon attribute (see Table 2-4 through Table 2-9).

Table 2-12: Example Input for Input Scheme 2, for a Notional GB Incident

Required Input		
Icon Index	Inhaled Concentration Time (mg-min/m^3)	
	Choice 1	Choice 2
1	0.03	55.00
2	0.21	345.40
3	0.00	0.00
4	0.03	47.60
5	0.01	0.01

6. Table 2-13 shows how the Effective CBRN Challenge as calculated by Input Scheme 1 differs from either set of Input Scheme 2 inputs. In each case, the incident scenario is the same, but because Input Scheme 1 uses time-resolved icon attributes, its Effective CBRN Challenge reflects the fact that nobody was wearing IPE when the incident began, but several icons donned masks quickly, and the breathing rates for several icons also changed as they reacted to the incident. The results for Input Scheme 2 reflect different user assumptions about breathing rate and use of IPE, but neither case matches will with the result from Input Scheme 1.

7. Even without the details of how the Effective CBRN Challenge is used to estimate casualties, it is clear from Table 2-13 that three different ways of representing the same incident scenario can result in different casualty estimates.[40] In general, Input Scheme 1 better reflects operational reality—personnel will react to a CBRN incident; the user should use Input Scheme 1 whenever possible.

Table 2-13: Example Differences in Effective CBRN Challenge Resulting from Using Different Input Schemes for the Same Notional GB Incident

	Input Scheme 1	Input Scheme 2—Choice 1	Input Scheme 2—Choice 2
Icon Index	Inhaled Concentration Time (mg-min/m^3)	Inhaled Concentration Time (mg-min/m^3)	Inhaled Concentration Time (mg-min/m^3)
1	7.54	0.03	55.00
2	60.4	0.21	345.40
3	0.00	0.00	0.00
4	9.41	0.03	47.60
5	0.01	0.01	0.01

2.2. METHODOLOGY PARAMETERS

1. For each parameter below, the user may specify a value. If no value is specified, the default defined in Table 2-14 will be used.

2. Medical Treatment Flag ($Flag_{MT}$). A binary parameter that determines whether the methodology should include the effects of specific therapies that counteract specific injuries (e.g. antibiotics), where such therapies exist. If set to NO, the "Untreated" human response models, which reflect supportive care alone, are used. If set to YES, the "Treated" human response models, reflecting the available specific therapies, are used. The default value is YES.

[40] For the curious reader, the best example of the difference is icon 4: under Input Scheme 1, icon 4 would become WIA and eventually RTD; under Input Scheme 2 (Choice 1), icon 4 would not become casualties; under Input Scheme 2 (Choice 2), icon 4 would become KIA if untreated, or WIA and eventually permanently CONV if treated.

3. Time at Injury Severity Level 4 sufficient to cause death from untreated chemical, nuclear blast, or nuclear burn injuries ($T_{death\text{-}CN\text{-}SL4}$). Untreated[41] casualties with a chemical, nuclear blast, or nuclear burn injury that spend this threshold amount of time at Severity Level 4 are assumed to die. The default value is 15 minutes.

   a. When $Flag_{MT}$ = Yes (the default value), all such casualties are KIA, because once a casualty reaches a MTF, medical treatment models are used to determine the outcome.

   b. When $Flag_{MT}$ = No, all casualties follow this assumption, even after reaching a MTF. Thus, there may be KIA and DOW casualties as a result of extended periods of Injury Severity Level 4.

4. Time to reach a medical treatment facility (T_{MTF}). The time required for an individual who is WIA to reach a MTF. Given the definitions of KIA and DOW, T_{MTF} determines whether a WIA who dies is KIA or DOW (see Figure 1-2). The default value is 30 minutes, and a user can specify any value up to (but excluding) 1 day—the methodology is built around the assumption that casualties reach an MTF *within* one day of becoming WIA.

5. The casualty criterion. The user-specifiable injury severity threshold above which an individual is declared WIA. The user may choose between WIA(1^+), WIA(2^+), and WIA(3^+). WIA(1^+) will typically result in individuals being declared casualties and then reporting to the medical system sooner than would WIA(2^+) or WIA(3^+) (see Figure 1-1). Methodologically, reporting to the medical system for injuries of lower severity results in fewer deaths and more personnel in the medical system (individuals are less likely to die before reaching an MTF). The default value is WIA(1^+).

Table 2-14: Default Values for User-Specifiable Parameters

Parameter	Default
Time to Reach a Medical Treatment Facility (T_{MTF})	30 minutes
Time at Severity Level 4 Sufficient to Cause Death From Chemical, Nuclear Blast, or Nuclear Burn Injuries ($T_{death\text{-}CN\text{-}SL4}$)	15 minutes
Medical Treatment Flag ($Flag_{MT}$)	Yes
Casualty Criterion	WIA(1^+)

[41] Including *not yet treated* casualties en route to a MTF.

CHAPTER 3 EFFECTIVE CBRN CHALLENGE ESTIMATION

This chapter provides the general framework for calculating the Effective CBRN Challenge from the inputs described in Chapter 2—it discusses the CHALLENGE step of the methodology. Special considerations for certain challenge types are fully described in Chapter 4, sections 4.2 through 4.4. The CBRN Challenge inputs needed for the equations in this chapter (X_{Q,n,t_k}) must be derived from a hazard prediction model.

3.1. INPUT SCHEME 1

1. For each challenge type other than inhaled chemical agent peak concentration, each icon's Effective CBRN Challenge is estimated using Equation 3-1, which incrementally sums (over time) the portion of the CBRN Challenge that becomes the Effective CBRN Challenge. See Table 2-11 for example input that would be used with Equation 3-1.

$$X_{Q,n}^{eff} = \sum_{k=1}^{f} \frac{(X_{Q,n,t_k} - X_{Q,n,t_{k-1}}) \cdot Z}{APF_{Q,n,t_{k-1}}}, \quad (3\text{-}1)$$

where:

$X_{Q,n}^{eff}$ is the Effective CBRN Challenge for challenge type Q and icon *n*,

t_k is the time variable,

t_0 is the first time point with non-zero CBRN Challenge,

t_f is the time at which the CBRN challenge ends,

X_{Q,n,t_k} is the CBRN Challenge for challenge type Q and icon *n* at time t_k (derived from the output of a hazard prediction model),

$APF_{n,t_{k-1}}$ is the Aggregate Protection Factor for icon *n* for time $t_{k-1} \leq t < t_k$, and

Z is a special factor whose value depends on the context, per the following list:

a. For an inhaled chemical agent challenge, Z is the unitless factor described in Table 2-3 (related to the breathing rate icon attribute). The

value can vary by timestep and icon, so Z becomes $Z_{n,t_{k-1}}$.

b. For an inhaled biological agent challenge, Z is the breathing rate icon attribute [m^3/min]. Table 2-3 lists default and suggested values. The value can vary by timestep and icon, so Z becomes $Z_{n,t_{k-1}}$.

c. For a percutaneous liquid chemical agent challenge, Z is the body surface area icon attribute [m^2]. The default value is 1 m^2, and section 2.1.4. contains user guidance relating to changing the value.

d. For a RDD challenge, Z is a dose conversion factor—it is used to convert from units of radioactivity (kBq per area or volume) to units of absorbed dose (gray per hour). Dose conversion factors do not vary with time or by icon, but they are isotope-specific and there are different values for cloudshine, groundshine, and skin contamination. Table 3-1 provides default values.

Table 3-1: Suggested Dose Conversion Factors for RDDs for Selected Isotopes (Daughter Products Included)

Isotope*	Cloudshine [(Gy/hr)/(kBq/m^3)]†		Groundshine [(Gy/hr)/(kBq/m^2)]†		Skin Contamination [(Gy/hr)/(kBq/m^2)]†
	Whole-Body ($Z_{RDD,wb,cld,r}$)	Cutaneous ($Z_{RDD,cut,cld,r}$)	Whole-Body ($Z_{RDD,wb,grd,r}$)	Cutaneous ($Z_{RDD,cut,grd,r}$)	Cutaneous ($Z_{RDD,cut,s,r}$)
^{60}Co	6.4 x 10^{-7}	7.3 x 10^{-7}	8.5 x 10^{-9}	9.9 x 10^{-9}	7.8 x 10^{-8}
^{90}Sr	3.8 x 10^{-11}	4.6 x 10^{-8}	1.0 x 10^{-12}	5.0 x 10^{-10}	3.5 x 10^{-7}
^{131}I	9.2 x 10^{-8}	1.5 x 10^{-7}	1.4 x 10^{-9}	2.3 x 10^{-9}	1.6 x 10^{-7}
^{137}Cs	1.5 x 10^{-7}	2.3 x 10^{-7}	2.1 x 10^{-9}	6.9 x 10^{-9}	1.6 x 10^{-7}
^{192}Ir	2.0 x 10^{-7}	2.8 x 10^{-7}	2.9 x 10^{-9}	4.4 x 10^{-9}	1.9 x 10^{-7}
^{238}Pu	2.5 x 10^{-11}	2.1 x 10^{-10}	3.0 x 10^{-12}	3.5 x 10^{-11}	3.7 x 10^{-10}
^{241}Am	4.1 x 10^{-9}	6.5 x 10^{-9}	9.9 x 10^{-11}	3.0 x 10^{-10}	1.9 x 10^{-9}

* ^{90}Sr is primarily a beta-emitter; the other isotopes are primarily gamma emitters.

† Values in this table were converted from (Sv/s)/(Bq/m^3) to (Gy/hr)/(kBq/m^3), (Sv/s)/(Bq/m^2) to (Gy/hr)/(kBq/m^2), or (μSv/hr)/(Bq/cm^2) to (Gy/hr)/(kBq/m^2) assuming a relative biological effectiveness (RBE) of 1.[42] For cloudshine, the effective dose was multiplied by 1.4 to estimate ambient dose.

[42] Cloudshine: Keith F. Eckerman and Jeffrey C. Ryman, *External Exposure to Radionuclides in Air, Water, and Soil*, Federal Guidance Report No. 12, EPA-402-R-93-081 (Washington, DC: U.S. Environmental Protection Agency, September 1993), 59, 61, 64, 65, 69, 72. Groundshine: ibid., 95, 97, 100, 101, 105, 108. Skin contamination: International Atomic Energy Agency (IAEA), *Generic Procedures for Assessment and Response During a Radiological Emergency*, IAEA-TECDOC-1162 (Vienna: IAEA, 2000), 103–104.

e. For a fallout groundshine challenge, Z is a gamma-to-beta dose conversion factor—it is used to calculate the beta radiation dose based on the gamma radiation dose. Table 3-2 provides default values.

f. For a fallout skin contamination challenge, Z is a dose conversion factor—it is used to convert from units of radioactivity (kBq per area) to units of absorbed dose (gray per hour). The dose conversion factor does not vary by icon, and its variance with time is sufficiently slow and low-magnitude that it can be ignored. Table 3-2 provides default values.

Table 3-2: Suggested Conversion Factors for Fallout

Time After Detonation	Groundshine* ($Z_{FO,cut,grd-\beta}$) [(Gy from β)/Gy from γ)]	Skin Contamination† ($Z_{FO,cut,s}$) [(Gy/hr)/(kBq/m^2)]
0.5 hours	9.6	N/A
1 hour	8.2	2.62×10^{-7}
2 hours	7.8	2.59×10^{-7}
4 hours	9.5	2.59×10^{-7}
6 hours	11.7	2.59×10^{-7}
12 hours	13.7	2.57×10^{-7}
24 hours (1 day)	10.9	2.54×10^{-7}
48 hours (2 days)	8.2	2.49×10^{-7}
72 hours (3 days)	6.7	2.46×10^{-7}
168 hours (1 week)	5.0	2.41×10^{-7}
336 hours (2 weeks)	5.3	2.41×10^{-7}
720 hours (1 month)	6.7	2.43×10^{-7}
1440 hours (2 months)	8.5	2.41×10^{-7}
2880 hours (4 months)	9.6	2.38×10^{-7}
4320 hours (6 months)	11.0	2.38×10^{-7}
6480 hours (9 months)	16.0	2.41×10^{-7}
8760 hours (1 year)	26.5	2.41×10^{-7}
17,520 hours (2 years)	88.1	2.43×10^{-7}

* For bare skin exposed to mixed fission products, 120 cm above ground.[43]

† For mixed fission products and a basal cell layer depth of 40 μm.[44]

[43] Neil M. Barss and Ronald L. Weitz, "Reconstruction of External Dose for Beta Radiation Sources of Nuclear Weapon Origin," *Health Physics* 91, no. 4 (2006): 379–389, 385.

[44] Defense Threat Reduction Agency (DTRA), *Standard Method ED04 – Skin Dose from Dermal Contamination*, 1.3 ed. (Fort Belvoir, VA: DTRA, 31 January 2010), 9.

2. For chemical agent peak concentration, Equation 3-2 is used to identify the highest inhaled chemical agent concentration, after accounting for the APF.

$$X_{Q,n}^{eff} = MAX\left(\frac{X_{Q,n,t_k}}{APF_{n,t_k}}\right), \text{ for } 0 \le k \le f, \tag{3-2}$$

where all variables are as defined for Equation 3-1.

3.2. INPUT SCHEME 2

Each icon's Effective CBRN Challenge is not estimated by the methodology; rather, it is provided by the user as input (see Table 2-12 for example input).

CHAPTER 4 CHEMICAL, RADIOLOGICAL, AND NUCLEAR HUMAN RESPONSE AND CASUALTY ESTIMATION

This chapter begins with a summary of the CRN modeling framework. Then, in separate sections for chemical agents, radiological agents, and nuclear effects, it discusses assumptions, limitations, and constrains, and describes, on an agent/effect-specific basis, how the methodology uses the Effective CBRN Challenge to estimate human response and casualties, including one flowchart per agent/effect that summarizes the process. In short, this chapter discusses the RESPONSE and STATUS steps of the methodology for CRN agents and effects.

4.1. CRN MODEL FRAMEWORK

4.1.1. Human Response

1. Each CRN agent and effect is associated with at least one challenge type (listed in section 1.3.1). Each challenge type is further associated with a set of Effective CBRN Challenge ranges (listed in the agent/effect parts of sections 4.2, 4.3, and 4.4).

2. Effective CBRN Challenge ranges are a set of bins into which an icon may be placed, depending on its Effective CBRN Challenge. Each bin is associated with a specific Injury Profile.

3. Injury Profiles:

   a. Represent the time-dependent severity of symptoms manifested in physiological systems expected to manifest symptoms earliest and at the highest severity (lesser symptoms are ignored).

   b. Describe clinically differentiable sets of symptoms the individuals in an icon will experience.

   c. Represent the typical individual with the mid-range challenge, explicitly ignoring the distribution of challenge within a challenge range and variation in the response of the challenged population to a given challenge.

   d. Do not account for the synergy of multiple simultaneous challenges, beyond the generation of Composite Injury Profiles (described below).

4. If an icon receives multiple challenges,[45] a Composite Injury Profile is produced by overlaying the Injury Profiles and selecting the maximum Injury Severity Level at each time point (with limited exception for combined nuclear effects, synergy of multiple challenges is not considered). Figure 4-1 provides the logic for generating Composite Injury Profiles, and Figure 4-2 is an example of a Composite Injury Profile based on three notional Injury Profiles.

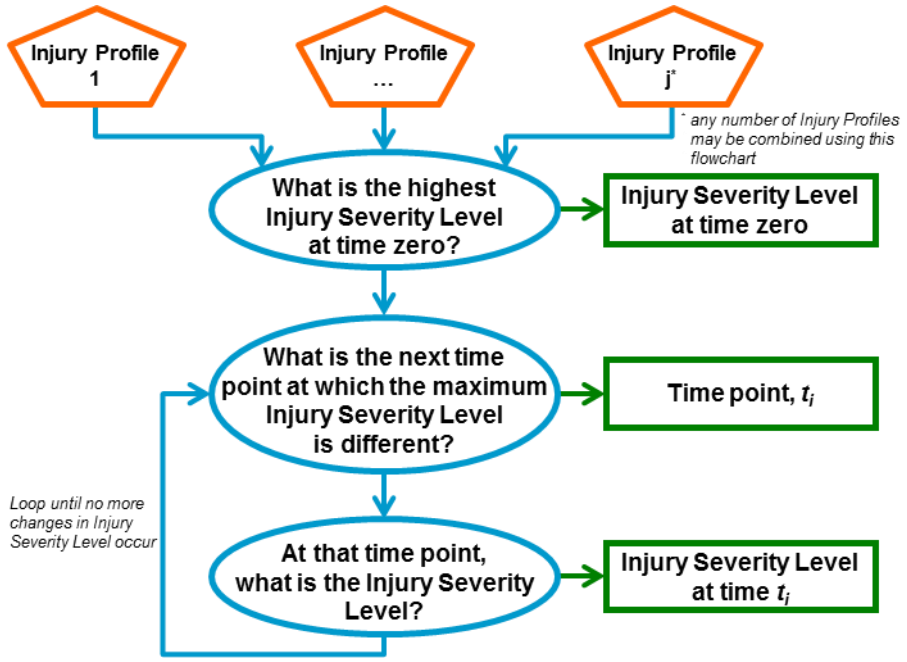


Figure 4-1: Flowchart for Generation of Composite Injury Profiles

[45] For example, multiple chemical agent challenges, or one chemical and one radiological challenge.

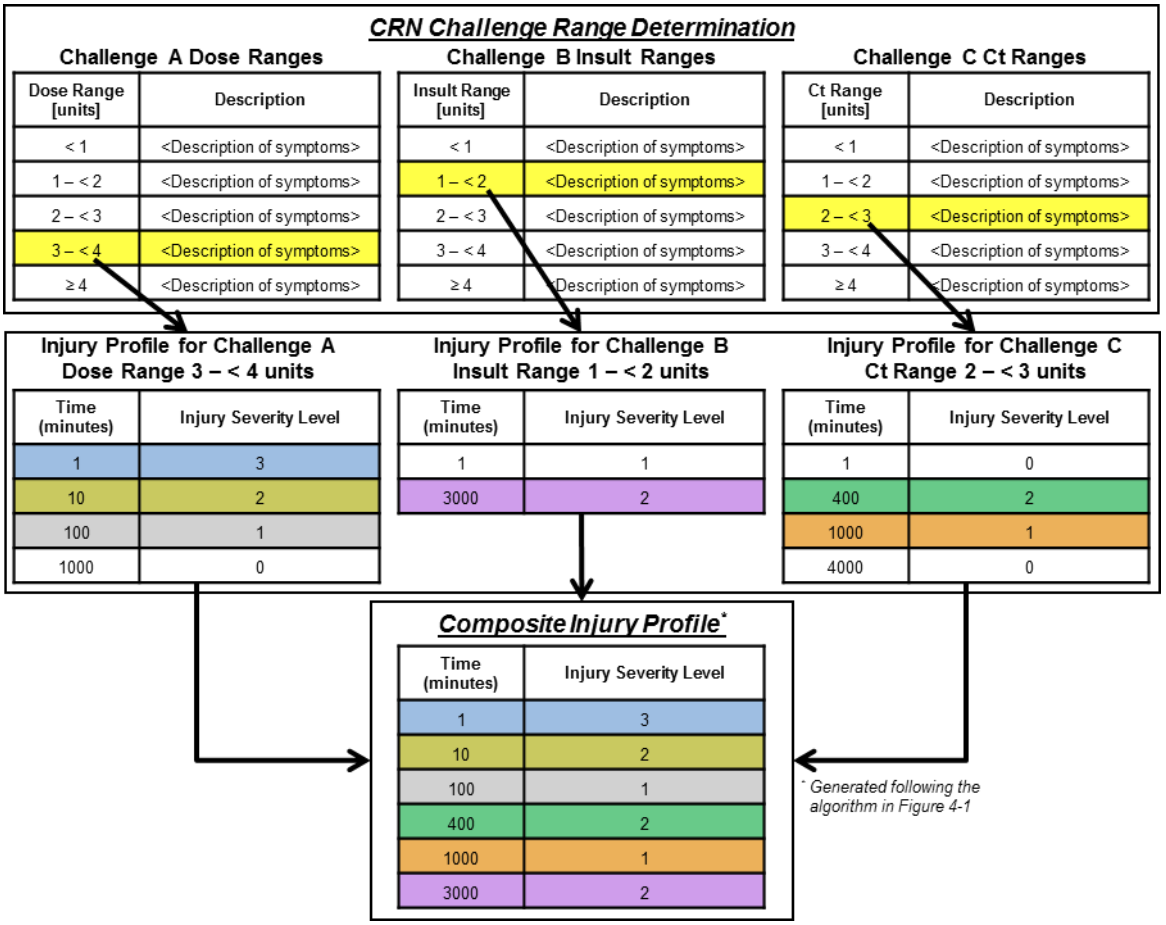


Figure 4-2: Notional Example of Composite Injury Profile Generation

5. The (Composite) Injury Profile is input to the casualty estimation portion of the methodology.

6. For the untreated models ($Flag_{MT}$ = No), Injury Profiles dictate when changes in casualty status occur. All individuals in an icon are estimated to exhibit the same human response. Thus, the status of any specific icon at any specific time is known. The one exception to this rule is for icons that receive a thermal challenge from a nuclear detonation while occupying a vehicle or shelter (see section 4.4.4).

7. When medical treatment is considered ($Flag_{MT}$ = Yes), Injury Profiles are only used until the icon enters the medical system—the Injury Profile is used to determine when the individuals become WIA, and if/when the casualties become KIA. Subsequently, the medical treatment models determine if/when the casualties become DOW, CONV, or RTD. Many medical treatment models are probabilistic; they must be applied to the entire population that has presented to the medical system instead of to each icon. Thus, when medical treatment is included, the outcome for any specific icon of interest is not known.

8. Medical treatment outcome tables (such as Table 4-3, for GB) specify how outcomes for the population that presents to the medical system, binned by Effective CBRN Challenge range, are *reported*. For each Effective CBRN Challenge range:

a. The KIA column specifies what fraction of casualties are reported as KIA. By definition, KIAs occur on day 1.

b. The WIA column specifies what fraction of casualties are reported as WIA and the day on which they are reported as such. If the casualty criterion affects reporting, different values are reported for different casualty criteria.

c. The DOW, CONV, and RTD columns specify what fraction of casualties are reported as DOW, CONV, or RTD and they day on which they are reported as such.

d. Note that DOW, CONV, and RTD are always *reported* on the day after *entering* that category (in accordance with the reporting rules from section 1.6.4.3.).

4.1.2. Casualty Estimation

1. In all cases, individuals become WIA as dictated by their icon's Injury Profile and the logic in Figure 1-1.

2. KIA and DOW.

a. In general, Equation 4-1 is used to determine whether a casualty who dies is KIA or DOW: if Equation 4-1 is TRUE, the casualty is KIA, and if it is false, the casualty is DOW.

$$T_{death,Q,n} < T_{MTF} + T_{WIA,n}, \quad (4\text{-}1)$$

where:

$T_{death,Q,n}$ is the time at which the casualty is estimated to die from injuries caused by challenge type Q,

T_{MTF} is as defined in section 2.2 (default value of 30 minutes, per Table 2-14), and

$T_{WIA,n}$ is the time at which icon *n* was declared WIA.

b. Untreated[46] chemical, nuclear blast, and nuclear burn casualties are estimated to die if their Injury Severity level 4 for longer than $T_{death\text{-}CN\text{-}SL4}$. $T_{death,Q,n}$ becomes $T_{death,CN,n}$, which is estimated according to Equation 4-4.

$$T_{death,CN,n} = T_{SL4,n} + T_{death\text{-}CN\text{-}SL4}, \quad (4\text{-}2)$$

where:

$T_{SL4,n}$ is the time at which icon *n*'s Injury Severity Level becomes 4, and

$T_{death\text{-}CN\text{-}SL4}$ is as defined in Section 2.2 (default value of 15 minutes, per Table 2-14).

c. Treated chemical, nuclear blast, and nuclear casualties are estimated to DOW if so indicated by their medical treatment outcomes table (tables located in sub-parts of section 4.2).

d. For either value of $Flag_{MT}$, RDD, fallout, and initial whole-body radiation (nuclear) casualties are estimated to die if their icon's total whole-body dose [Gy] is greater than a threshold dose.

1) For RDDs and fallout, that threshold is $D_{death,wb,n}$, which is calculated as described in section 4.3.5. Time of death is estimated by Equation 4-15.

2) For initial whole-body radiation (nuclear), that threshold is 4.5 Gy. Time of death is estimated by Equation 4-17.

3. CONV and RTD

a. If $Flag_{MT}$ = No, casualties become RTD if/when their Injury Severity Level returns to zero, as indicated by their icon's Injury Profile. CONV is not estimated.

b. If $Flag_{MT}$ = Yes, casualties become CONV and/or RTD as dictated by the medical treatment outcomes table for the challenge that caused their injury (tables located in sub-parts of section 4.2).

4. The agent/effect-specific flowcharts in sections 4.2, 4.3, and 4.4 contain declarations of changes in casualty category, such as "Icon is WIA." Each flowchart also notes that the days on which those changes occur are passed to Equation 4-3,

[46] Including *not yet treated* casualties en route to a MTF (relevant when $Flag_{MT}$ = Yes). Once such casualties reach a MTF, their outcomes are determined by the appropriate medical treatment model.

which sums, by icon, the number of individuals in a given casualty category, to generate the overall daily casualty estimate.

$$New_{CAT}(d) = \sum_{n} (i_n \cdot f_{CAT}(d)) , \quad (4\text{-}3)$$

where:

CAT is a casualty category (KIA, WIA, DOW, CONV, or RTD),

$New_{CAT}(d)$ is the number of individuals who are reported as CAT on day d, rounded to the nearest integer (typically, this means they enter CAT on day d and remain there until at least the next day, but icons assigned multiple casualty categories within a single day are reported according to the rules in section 1.6.4.3),

i_n is the number of individuals in icon *n*,

$f_{CAT}(d)$ is the fraction of icon *n* that is reported as CAT on day d; the value is typically 1.0, but may be less if $Flag_{MT}$ = Yes.

2. After Equation 4-3 is applied to each casualty category on each day, the methodology continues by reporting the outputs, as described in Chapter 6.

4.2. CHEMICAL AGENT MODELS

This section begins with a discussion of methodological features, assumptions, and limitations that apply only to chemical agents. Following that is one section on each chemical agent, each of which describes in full detail how the methodology uses the Effective CBRN Challenge to estimate human response and casualties for one agent. For each agent, there is a flowchart summarizing the process from Effective CBRN Challenge to casualty estimate. As necessary, agent-specific equations for estimating Effective CBRN Challenge are also provided.

4.2.1. Assumptions

1. All individuals are 70-kilogram males.

2. All chemical agents follow Haber's law, which states that the severity of toxic effects from chemical agents depends only upon the total concentration time or dose, and is independent of the duration over which the concentration time or dose was accumulated. The intent is for Study Draft 3 to contain the option to use a toxic load formulation instead of Haber's law. Although it is not clear whether Haber's law or toxic load produces a more accurate casualty estimate, having the option will

allow the user to generate a range of estimates by running the methodology once for each option.

4.2.2. GB

1. Figure 4-3 summarizes the human response and casualty estimation processes for GB.

2. Inhalation is the only GB challenge type considered. Each icon's inhaled Ct ($X^{eff}_{GB,ih,n}$) is estimated according to Chapter 3.

3. Assumption. Percutaneous exposure to GB vapor and liquid are negligible.

4. For each inhaled GB vapor Ct range, Table 4-1 summarizes the associated symptoms, Table 4-2 fully describes the associated Injury Profile for untreated personnel, and Table 4-3 describes the outcomes associated with medical treatment.

Table 4-1: Inhaled GB Vapor Ct Ranges

Inhaled Ct Range (mg-min/m^3)	Description
< 0.2	No observable effect in the majority of the population
0.2 – < 1	Miosis in 10% – 90%, rhinorrhea, transient tightness of the chest
1 – < 6.5	Rhinorrhea, dimmed vision, mild headache, excessive airway secretions induce cough, maximal ocular disease
6.5 – < 12	Runny nose, dim vision or eye pain with sensitivity to light, nausea, frequent cough
12 – < 25	Maximal secretions and eye effects, vomiting, abdominal cramps, severe headache with anxiety and confusion, tight chest, convulsions, severe effects in 10% – 50%
25 – < 27	Twitching, weakness, diarrhea, convulsions progressing to collapse and respiratory failure, lethality in 10%
≥ 27	Collapse and respiratory failure, severe effects in 90%, lethality in ≥ 50%

Table 4-2: Inhaled GB Vapor Untreated Injury Profiles

Time Point (min)	Inhaled Ct Range					
	0.2 – < 1 mg-min/m^3	1 – < 6.5 mg-min/m^3	6.5 – < 12 mg-min/m^3	12 – < 25 mg-min/m^3	25 – < 27 mg-min/m^3	≥ 27 mg-min/m^3
1	0	2	2	3	3	4
3	1	2	2	3	4	4
15	1	2	2	3	3	4*
150	0	2	2	3	3	4
1000	0	1	2	2	2	4
2880	0	1	1	2	2	4
8640	0	1	1	1	2	4

* According to the default value for $T_{death\text{-}CN\text{-}SL4}$, death would be modeled at this point.

Table 4-3: GB Medical Treatment Outcome Reporting

Inhaled Ct Range (mg-min/m^3)	KIA	WIA	DOW	CONV	RTD
0.2 – < 1	0%	WIA(2^+ or 3^+) 0% WIA(1^+) Day 1: 100%	0%	0%	Day 2: 100%
1 – < 6.5	0%	WIA(3^+) 0% WIA(1^+ or 2^+) Day 1: 100%	0%	0%	Day 2: 100%
6.5 – < 12	0%	WIA(3^+) 0% WIA(1^+ or 2^+) Day 1: 100%	0%	0%	Day 3: 100%
12 – < 25	0%	Day 1: 100%	0%	0%	Day 5: 33.3% Day 6: 33.3% Day 7: 33.3%
25 – < 540	0%	Day 1: 100%	0%	Day 7: 100%	0%
≥ 540	0%	0%	Day 15: 100%	0%	0%

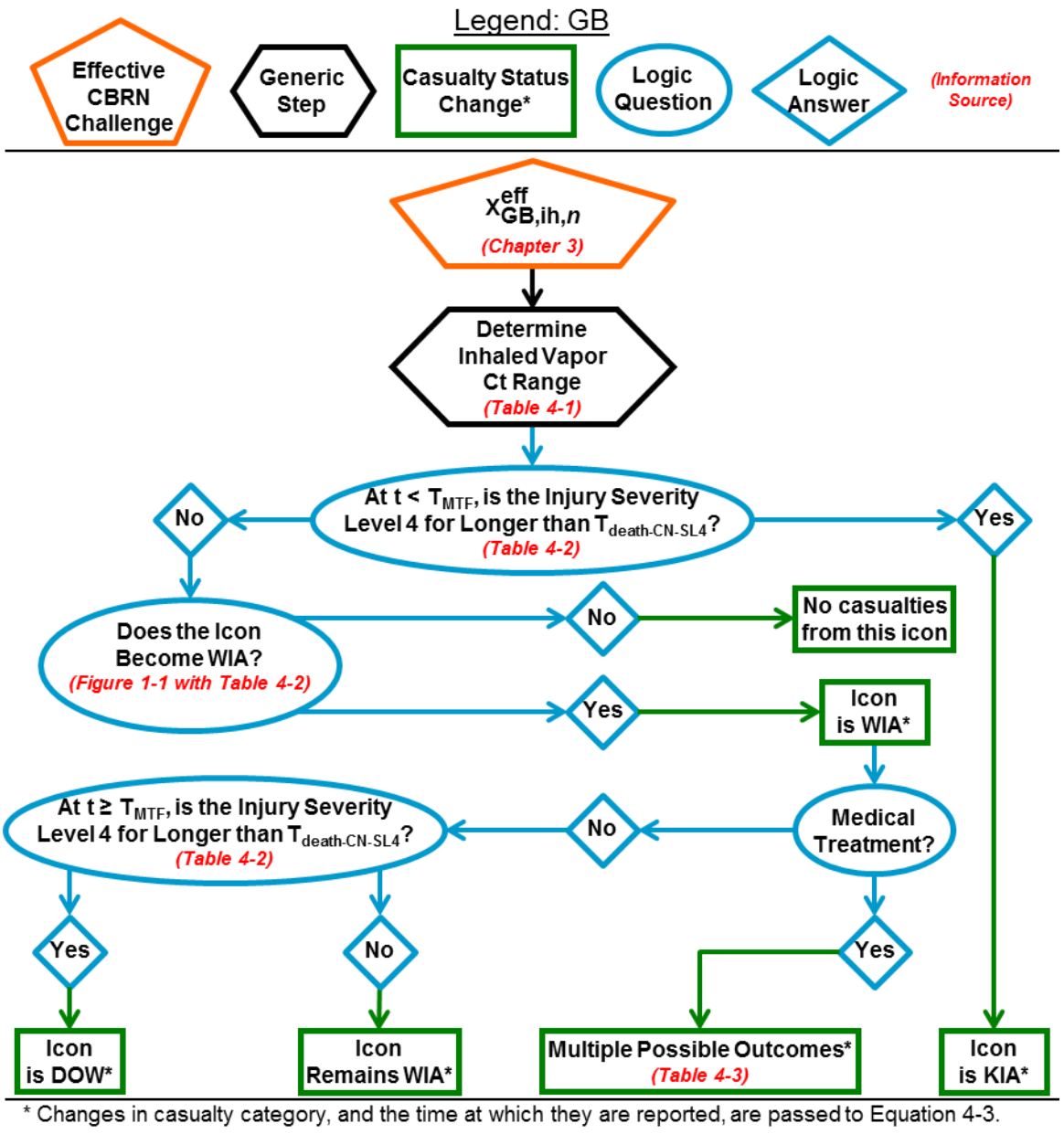


Figure 4-3: Human Response and Casualty Estimation Flowchart for GB

4.2.3. VX

1. Figure 4-4 summarizes the human response and casualty estimation processes for VX.

2. Inhalation and percutaneous liquid are the challenge types considered for VX. Each icon's inhaled Ct ($X^{eff}_{VX,ih,n}$) and percutaneous liquid dose ($X^{eff}_{VX,pc,n}$) are estimated according to Chapter 3.

3. Assumptions.

   a. Percutaneous exposure to VX vapor is negligible.

   b. Human response due to inhaled VX vapor and percutaneous VX liquid are independent of one another—the effects of each challenge type are modeled separately, and are only combined in the form of a Composite Injury Profile.

4. For each inhaled VX vapor Ct range, Table 4-4 summarizes the associated symptoms and Table 4-5 fully describes the associated Injury Profile for untreated personnel. Likewise, Table 4-6 and Table 4-7 describe the symptoms and Injury Profiles for each percutaneous VX liquid dose range. Finally, Table 4-8 describes the outcomes associated with medical treatment.

Table 4-4: Inhaled VX Vapor Ct Ranges

Inhaled Ct Range (mg-min/m^3)	Description
< 0.01	No observable effect in the majority of the population
0.01 – < 0.1	Miosis in 10% – 90%; rhinorrhea; transient tightness of the chest
0.1 – < 3	Rhinorrhea; dimmed vision; mild headache; excessive airway secretions induce cough; maximal ocular disease
3 – < 6	Runny nose; dim vision or eye pain with sensitivity to light; nausea; frequent cough
6 – < 9	Maximal secretions and eye effects; vomiting; abdominal cramps; severe headache with anxiety and confusion; tight chest; convulsions; severe effects in 10% – 50%
9 – < 10	Twitching; weakness; diarrhea; convulsions progressing to collapse and respiratory failure; lethality in 10%
≥ 10	Collapse and respiratory failure; severe effects in 90%; lethality in ≥ 50%

Table 4-5: Inhaled VX Vapor Untreated Injury Profiles

Time Point (min)	Inhaled Ct Range					
	0.01 – < 0.1 mg-min/m^3	0.1 – < 3 mg-min/m^3	3 – < 6 mg-min/m^3	6 – < 9 mg-min/m^3	9 – < 10 mg-min/m^3	≥ 10 mg-min/m^3
1	0	2	2	3	3	4
3	1	2	2	3	4	4
15	1	2	2	3	3	4*
150	0	2	2	3	3	4
1000	0	1	2	2	2	4
2880	0	1	1	2	2	4
8640	0	1	1	1	2	4

* According to the default value for $T_{death\text{-}CN\text{-}SL4}$, death would be modeled at this point.

Table 4-6: Percutaneous VX Liquid Dose Ranges

Dose Range (mg)	Description
< 0.8	No observable effect in the majority of the population
0.8 – < 1.6	Muscle twitching and fasciculation; chest tightness and shortness of breath; episodes of vomiting; severe effects in 10%
1.6 – < 2.3	Severe generalized trembling with possible convulsions; feelings of confusion and anxiety; respiratory congestion and bronchorrhea; severe effects in ≥ 50%; lethality in 10%
≥ 2.3	Unconsciousness; paralysis; breathing stops completely or struggling to breathe; lethality in ≥ 50%

Table 4-7: Percutaneous VX Liquid Untreated Injury Profiles

Time Point (min)	Percutaneous Dose Range			Time Point (min)	Percutaneous Dose Range		
	0.8 – < 1.6 mg	1.6 – < 2.3 mg	≥ 2.3 mg		0.8 – < 1.6 mg	1.6 – < 2.3 mg	≥ 2.3 mg
1	0	0	0	**100**	1	2	4
8	0	1	1	**150**	1	3	4
10	1	1	1	**360**	2	3	4
30	1	1	2	**1000**	1	3	4
36	1	1	4	**1440**	0	3	4
51	1	1	4*	**2400**	0	2	4

* According to the default value for $T_{death\text{-}CN\text{-}SL4}$, death would be modeled at this point.

5. Medical treatment-related outcomes for icons challenged via both inhalation and percutaneous liquid are dictated by the more severe challenge, where the severity of the challenge increases as one moves down the rows in Table 4-8.

Table 4-8: VX Medical Treatment Outcome Reporting

Inhaled Ct Range (mg-min/m^3)	Percutaneous Dose Range (mg)	KIA	WIA	DOW	CONV	RTD
0.01 – < 0.1		0%	WIA(2^+ or 3^+) 0% WIA(1^+) Day 1: 100%	0%	0%	Day 2: 100%
0.1 – < 3		0%	WIA(3^+) 0% WIA(1^+ or 2^+) Day 1: 100%	0%	0%	Day 2: 100%
3 – < 6	0.8 – < 1.6	0%	WIA(3^+) 0% WIA(1^+ or 2^+) Day 1: 100%	0%	0%	Day 3: 100%
6 – < 9	1.6 – < 2.3	0%	Day 1: 100%	0%	0%	Day 5: 33.3% Day 6: 33.3% Day 7: 33.3%
9 – < 200	2.3 – < 46	0%	Day 1: 100%	0%	Day 7: 100%	0%
≥ 200	≥ 46	0%	0%	Day 15: 100%	0%	0%

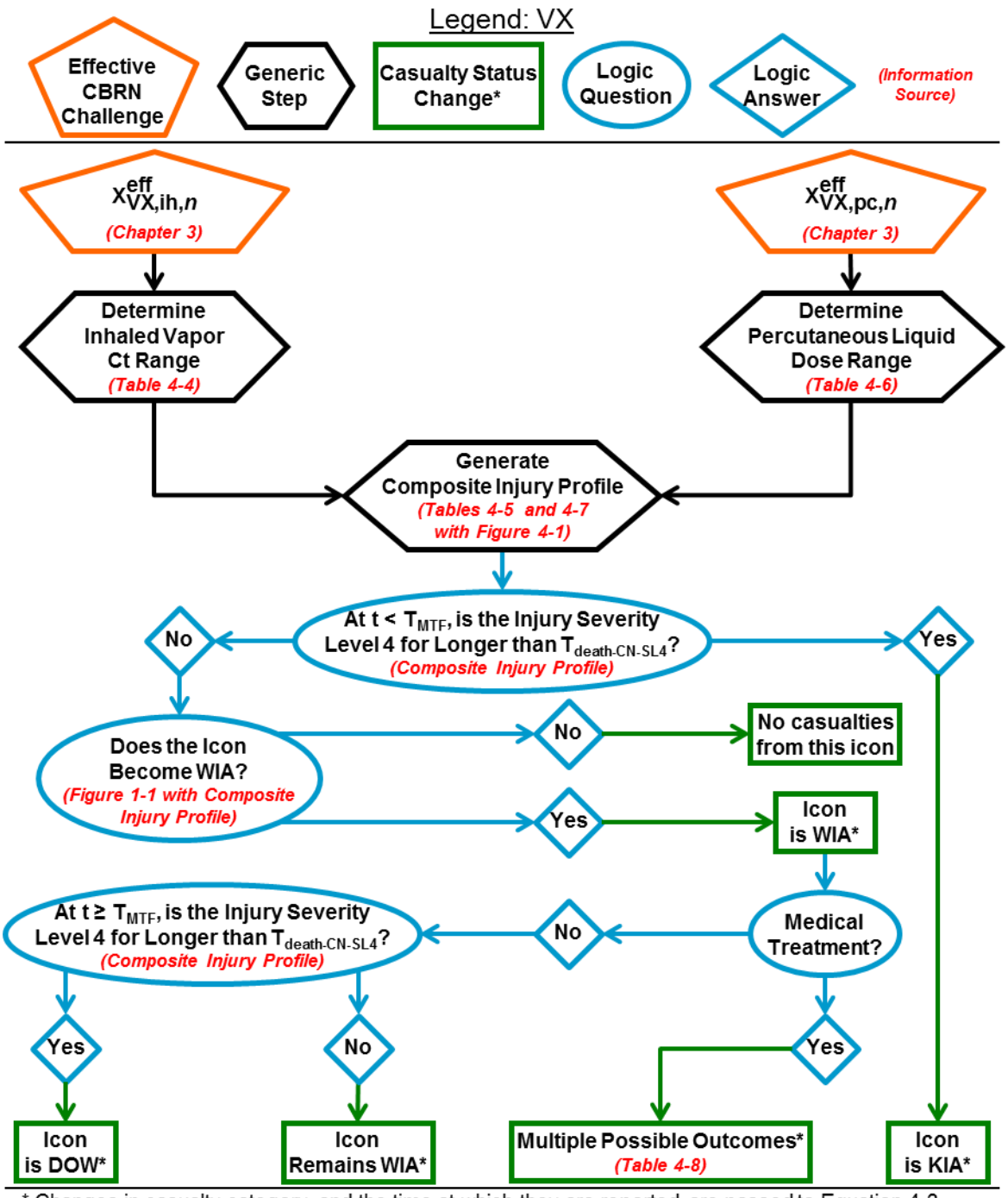


Figure 4-4: Human Response and Casualty Estimation Flowchart for VX

4.2.4. HD

1. Figure 4-5 summarizes the human response and casualty estimation processes for HD.

2. Inhalation, ocular vapor, and equivalent percutaneous vapor are the challenge types considered for HD.

a. Each icon's inhaled Ct ($X^{eff}_{HD,ih,n}$) is estimated according to Chapter 3.

b. Each icon's ocular vapor Ct ($X^{eff}_{HD,oc,n}$) is estimated according to Chapter 3, using percutaneous vapor data as input; the ocular vapor Ct is considered equivalent to the percutaneous vapor Ct.

c. Each icon's equivalent percutaneous vapor Ct ($X^{eff}_{HD,epc,n}$) is estimated using both percutaneous vapor and percutaneous liquid input data, according to Equation 4-4.[47]

$$X^{eff}_{HD,epc,n} = X^{eff}_{HD,pv,n} + X^{eff}_{HD,pl,n} \cdot CF_{HD}, \quad (4\text{-}4)$$

where:

$X^{eff}_{HD,epc,n}$ is the equivalent percutaneous vapor Ct for icon *n* [mg-min/m^3],

$X^{eff}_{HD,pv,n}$ is the percutaneous vapor Ct for icon *n* as calculated according to Chapter 3 [mg-min/m^3],

$X^{eff}_{HD,pl,n}$ is the percutaneous liquid dose for icon *n* as calculated according to Chapter 3 [mg], and

CF_{HD} is the percutaneous liquid to equivalent vapor conversion factor for HD [(mg-min/m^3) / (mg)], as defined in Equation 4-5.

$$CF_{HD} = \frac{ECt_{50\text{-severe}}(HD/PC/V)}{ED_{50\text{-severe}}(HD/PC/L)}, \quad (4\text{-}5)$$

where:

[47] Gene E. McClellan, George H. Anno, and Leigh N. Matheson, *Consequence Analytic Tools for NBC Operations Volume 3: Chemical Agent Exposure and Casualty Estimation* (Alexandria, VA: Defense Special Weapons Agency, 1998), 32–35.

$ECt_{50\text{-severe}}$(HD/PC/V) is the percutaneous HD vapor Ct [mg-min/m^3] required to produce severe effects in 50% of individuals,

$ED_{50\text{-severe}}$(HD/PC/L) is the percutaneous HD liquid dose [mg] required to produce severe effects in 50% of individuals, and

Table 4-9 provides recommended values for both parameters.

Table 4-9: Recommended Parameter Values for Equivalent Vapor Conversion Factor for HD

Parameter	Recommended Parameter Value*
$ECt_{50\text{-severe}}$(HD/PC/V)	500 mg-min/m^3
$ED_{50\text{-severe}}$(HD/PC/L)	600 mg

* Multiservice Publication, *Potential Military Chemical/Biological Agents and Compounds*, FM 3-11.9/MCRP 3-37.1B/NTRP 3-11.32/AFTTP(I) 3-2.55 (Washington, DC: U.S. Government Printing Office, January 2005), II-40.

3. Assumption. Human response due to inhaled HD vapor, percutaneous HD vapor, and percutaneous HD liquid are independent of one another—the effects of each challenge type are modeled separately, and are only combined in the form of a Composite Injury Profile.

4. Special consideration for HD casualty estimation. To account for very severe effects on the respiratory system due to hematopoietic system/bone marrow suppression and sepsis resulting from exposure to very high doses of percutaneous HD liquid, any icon for which $X^{eff}_{HD,pl,n}$ is > 1,400 mg is estimated to die at 336 hours (14 days), unless the Injury Profile indicates an earlier death.[48] This applies regardless of the value of $Flag_{MT}$.[49]

5. For each inhaled HD vapor Ct range, Table 4-10 summarizes the associated symptoms and Table 4-11 fully describes the associated Injury Profile for untreated personnel. Likewise, Table 4-12 and Table 4-13 describe the symptoms and Injury Profiles for each ocular HD vapor Ct range, and Table 4-14 and Table 4-15 describe the symptoms and Injury Profiles for each equivalent percutaneous HD vapor Ct range. Finally, Table 4-16 describes the outcomes associated with medical treatment.

[48] If the Injury Profile does not indicate an earlier death, $T_{death,HD,n}$ = 336 hours should be used in Equation 4-1 to determine whether the casualties are KIA or DOW.

[49] Julia K. Burr et al., *Proceedings of the NATO Chemical Human Response Subject Matter Expert Review Meeting, 21-22 April 2008, Munich, Germany*, IDA Document D-3883 (Alexandria, VA: IDA, August 2009), 66.

Table 4-10: Inhaled HD Vapor Ct Ranges

Inhaled Ct Range (mg-min/m^3)	Description
< 50	No observable effect in the majority of the population
50 – < 70	Nauseated; swallows often
70 – < 100	Dry mouth; dry cough; sneezing; runny nose; headache; nauseated; vomited once or twice; severe effects in 10% at 80 mg-min/m^3
100 – < 150	Sore throat; continuous cough; hoarseness; chest feels tight; headache; fever; severe effects in 50% at 135 mg-min/m^3
150 – < 250	Hurts to breathe; hacking cough; cannot speak; headache; dry heaves; fatigued from vomiting; severe effects in 90% at 230 mg-min/m^3
250 – < 1200	Awful chest pain; wheezing and shortness of breath; coughs up red colored mucous; lethality in 10% at 600 mg-min/m^3, in 50% at 1000 mg-min/m^3
≥ 1200	Very severe effects; lethality in 90% at 1700 mg-min/m^3

Table 4-11: Inhaled HD Vapor Untreated Injury Profiles

Time Point (hr)	Inhaled Ct Range					
	50 – < 70 mg-min/m^3	70 – < 100 mg-min/m^3	100 – < 150 mg-min/m^3	150 – < 250 mg-min/m^3	250 – < 1200 mg-min/m^3	≥ 1200 mg-min/m^3
1	0	0	0	1	1	1
4	0	0	0	1	2	2
6	0	1	1	2	2	2
8	1	1	1	2	2	2
20	0	1	1	2	2	2
24	0	1	1	2	3	3
36	0	1	2	3	3	3
48	0	1	2	3	3	4*
72	0	1	2	3	4*	4
168	0	0	2	3	4	4
336	0	0	1	2	4	4
720	0	0	0	1	4	4
1008	0	0	0	0	4	4

* According to the default value for $T_{death\text{-}CN\text{-}SL4}$, death would be modeled at this point.

Table 4-12: Ocular HD Vapor Ct Ranges

Ocular Ct Range (mg-min/m^3)	Description
< 4	No observable effect in the majority of the population
4 – < 26	Eyes sting; tears; blurred vision; miosis in 10% at 9 mg-min/m^3, in 50% at 25 mg-min/m^3; severe ocular effects in 10% at 28 mg-min/m^3
26 – < 50	
50 – < 70	Eyes feel gritty and sensitive to light; non-stop tears flood eyes; miosis in 90% at 67 mg-min/m^3
70 – < 100	Eyelids are puffy and eyes burn; eyes are too painful to keep open; severe ocular effects in 50% at 75 mg-min/m^3
≥ 100	Eyelids are swollen shut and burning; eyes are too painful to open; severe ocular effects in 90% at 200 mg-min/m^3

Table 4-13: Ocular HD Vapor Untreated Injury Profiles

Time Point (hr)	Ocular Ct Range				
	4 – < 26 mg-min/m^3	26 – < 50 mg-min/m^3	50 – < 70 mg-min/m^3	70 – < 100 mg-min/m^3	≥ 100 mg-min/m^3
1	0	0	0	0	0
2	0	0	0	0	1
3	0	0	0	1	2
4	0	0	1	2	2
5	0	1	1	2	2
6	0	1	2	2	2
9	1	1	2	2	2
11	1	1	2	2	3
12	1	2	2	3	3
18	2	2	2	3	3
36	1	2	2	3	3
60	0	1	2	3	3
108	0	0	2	3	3
168	0	0	2	2	2
504	0	0	1	1	1
672	0	0	0	0	0

Table 4-14: Equivalent Percutaneous HD Vapor Ct Ranges

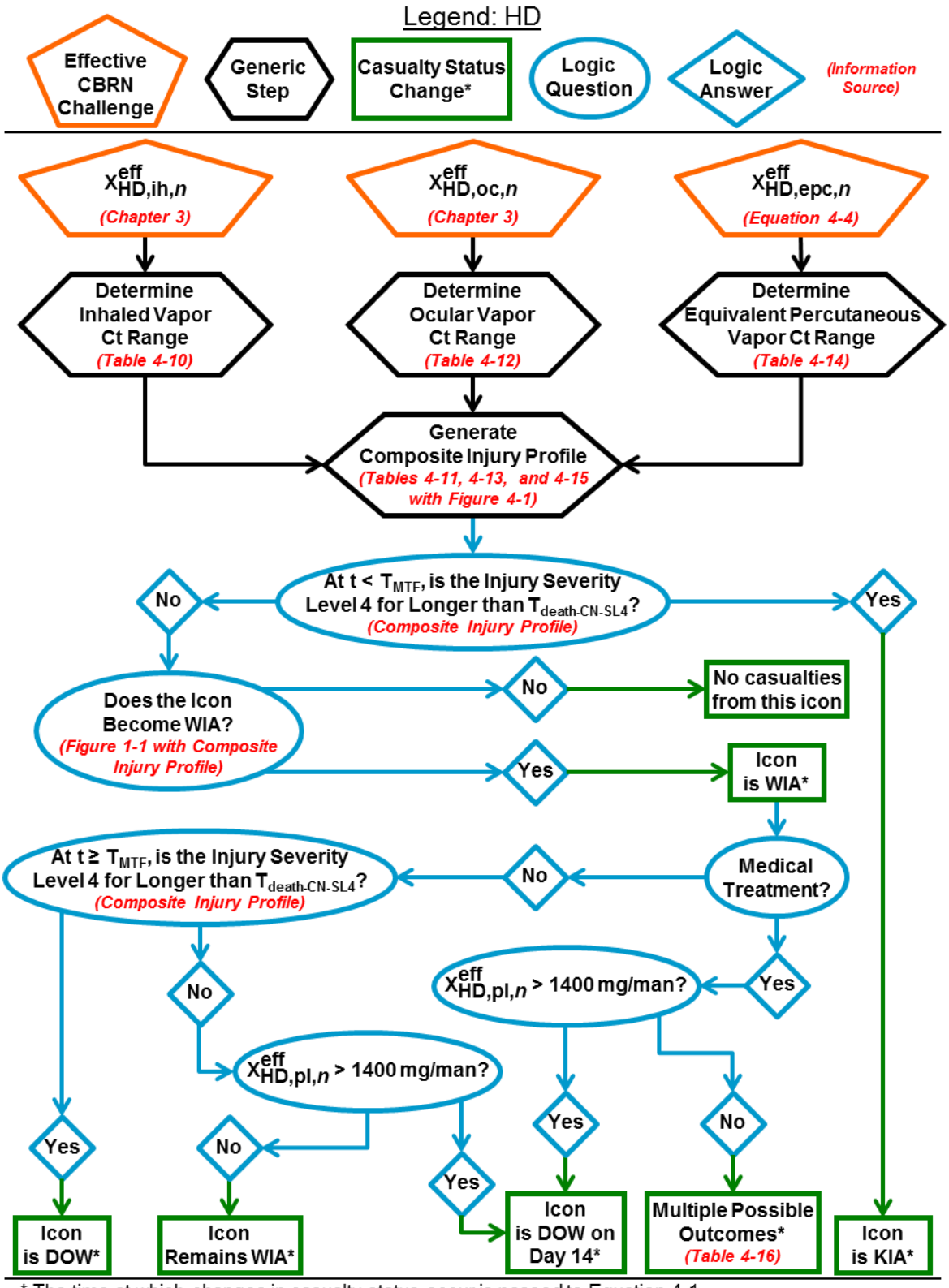
Equivalent Percutaneous Ct Range (mg-min/m^3)	Description
< 12	No observable effect in the majority of the population
12 – < 125	Skin sensitive to touch in tender areas (crotch, armpits, inside of elbow and knee); threshold effects in 10% at 19 mg-min/m^3, in 50% at 50 mg-min/m^3
125 – < 180	Skin sore in tender areas; painful when moving; redness of the skin; tiny blisters on hands and neck; threshold effects in 90% at 134 mg-min/m^3
≥ 180	Skin peels off leaving open raw areas and painful ulcers in tender areas; severe effects in 10% at 187 mg-min/m^3, in 50% at 500 mg-min/m^3, in 90% at 1337 mg-min/m^3; lethality in 10% at 6560 mg-min/m^3, in 50% at 10,000 mg-min/m^3, in 90% at 15,243 mg-min/m^3

Table 4-15: Equivalent Percutaneous HD Vapor Untreated Injury Profiles

Time Point (hr)	Equivalent Percutaneous Ct Range			Time Point (hr)	Equivalent Percutaneous Ct Range		
	12 – < 125 mg-min/m^3	125 – < 180 mg-min/m^3	≥ 180 mg-min/m^3		12 – < 125 mg-min/m^3	125 – < 180 mg-min/m^3	≥ 180 mg-min/m^3
1	0	0	0	**36**	1	1	3
2	0	0	1	**96**	0	1	3
5	0	0	2	**168**	0	0	3
18	0	1	2	**504**	0	0	1
24	0	1	3	**588**	0	0	0

Table 4-16: HD Medical Treatment Outcome Reporting

Ct Range (mg-min/m^3)	KIA	WIA	DOW	CONV	RTD
4 – < 12	0%	When criterion met: 100%	0%	0%	Day 4: 100%
12 – < 26	0%	When criterion met: 100%	0%	0%	Day 5: 100%
26 – < 50	0%	When criterion met: 100%	0%	0%	Day 6: 100%
50 – < 70	0%	When criterion met: 100%	0%	0%	Day 15: 100%
≥ 70	0%	100%	Day 2: 0.1% Day 3: 0.3% Day 4: 0.7% Day 5: 1.1% Day 6: 3.0% Days 7–17: 0.8% each	Day 43: 36.7%	Day 22: 7.5% Day 29: 9.6% Day 36: 14.7% Day 43: 17.5%



* The time at which changes in casualty status occur is passed to Equation 4-1.

Figure 4-5: Human Response and Casualty Estimation Flowchart for HD

4.2.5. CG

1. Figure 4-6 summarizes the human response and casualty estimation processes for CG.

2. Inhalation is the only CG challenge type considered. Each icon's inhaled Ct ($X^{eff}_{CG,ih,n}$) and peak inhaled concentration ($X^{eff}_{CG,[ih],n}$) are estimated according to Chapter 3.

3. Assumption. Percutaneous exposure to CG vapor and liquid are negligible.

4. Special consideration for CG casualty estimation. To account for a distinct mechanism of injury caused by high inhaled concentrations—thought to be phosgene passing through the blood-air barrier and into the pulmonary circulatory system, where it causes hemolysis and acute overextension of the right heart within minutes—any icon for which $X^{eff}_{CG,[ih],n}$ is > 820 mg/m^3 is estimated to die two minutes after inhaling such a concentration.[50] $T_{death,CG,n}$ = 2 minutes should be used in Equation 4-1 to determine whether the casualties are KIA or DOW.

5. For each inhaled CG vapor Ct range, Table 4-17 summarizes the associated symptoms, Table 4-18 fully describes the associated Injury Profile for untreated personnel. Likewise, Table 4-19 and Table 4-20 describe the symptoms and Injury Profiles for each peak CG concentration range. Finally, Table 4-21 describes the outcomes associated with medical treatment.

Table 4-17: Inhaled CG Vapor Ct Ranges

Inhaled Ct Range (mg-min/m^3)	Description
< 615	No observable effect in the majority of the population
615 – < 1150	After long latent phase: dyspnea, anxiety, dry and then wet cough, chest pain, nausea and vomiting, pulmonary edema
≥ 1150	After short latent phase: dyspnea, anxiety, dry and then wet cough, chest pain, nausea and vomiting, pulmonary edema

[50] Sean M. Oxford et al., *Parameters for Estimation of Casualties from Additional Chemical and Biological Agents (Draft)*, IDA Paper P-5140 (Alexandria, VA: IDA, to be published in 2015), 47, FOUO.

Table 4-18: Inhaled CG Vapor Untreated Injury Profiles

Time Point (min)	Inhaled Ct Range	
	615 – < 1150 mg-min/m^3	≥ 1150 mg-min/m^3
1	0	0
240	0	3
360	0	4
375	0	4*
720	3	4
900	4	4
915	4*	4

* According to the default value for $T_{death\text{-}CN\text{-}SL4}$, death would be modeled at this point.

Table 4-19: Peak Inhaled CG Vapor Concentration Ranges

Peak Inhaled Concentration Range (mg/m^3)	Description
< 12	No observable effect in the majority of the population
12 – 820	Mild eye and throat irritation; lacrimation; mild coughing; chest tightness; shortness of breath; nausea
≥ 820	Hemolysis; acute overextension of the right chamber of the heart; death within minutes

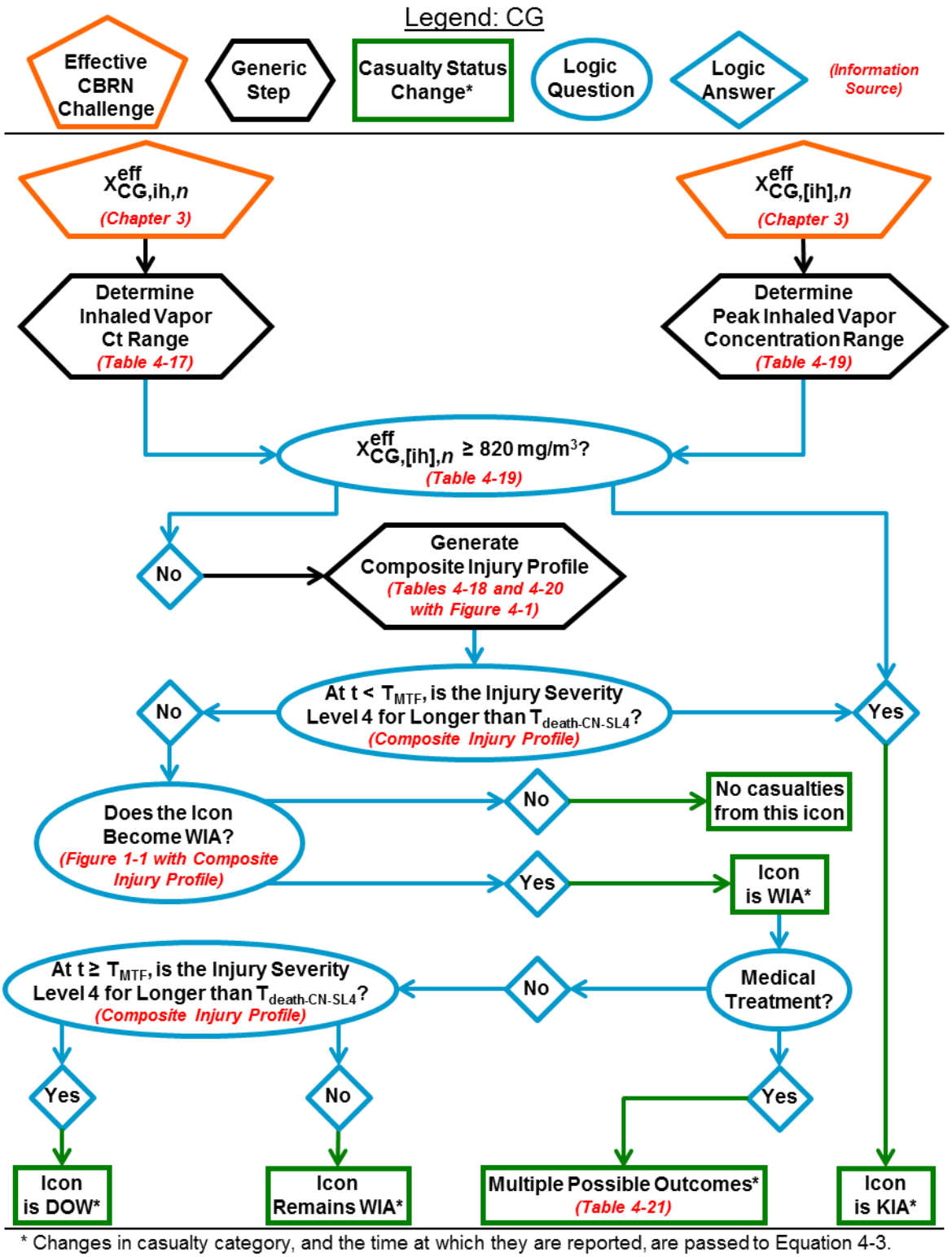
Table 4-20: Peak Inhaled CG Vapor Concentration Untreated Injury Profiles

Time Point (min)	Peak Inhaled Concentration Range	
	12 – < 820 mg/m^3	≥ 820 mg/m^3
1	1	0
2	1	4*
15	0	(N/A)

* Death is modeled at this point, per the special consideration for CG described in 4.2.5.4.

Table 4-21: CG Medical Treatment Outcome Reporting

Peak Inhaled Concentration Range (mg/m^3)	KIA	WIA	DOW	CONV	RTD
12 – < 820	0%	WIA(2$^+$ or 3$^+$) 0% WIA(1$^+$) Day 1: 100%	0%	0%	Day 2: 100%
≥ 820	100%	0%	0%	0%	0%
Inhaled Ct Range (mg-min/m^3)	**KIA**	**WIA**	**DOW**	**CONV**	**RTD**
615 – < 1150	0%	Day 1: 100%	0%	0%	Day 15: 100%
≥ 1150	0%	Day 1: 100%	Day 2: 100%	0%	0%



* Changes in casualty category, and the time at which they are reported, are passed to Equation 4-3.

Figure 4-6: Human Response and Casualty Estimation Flowchart for CG

4.2.6. Cl_2

1. Figure 4-7 summarizes the human response and casualty estimation processes for Cl_2.

2. Inhalation is the only Cl_2 challenge type considered. Each icon's inhaled Ct ($X^{eff}_{Cl2,ih,n}$) is estimated according to Chapter 3.

3. Assumption. Percutaneous exposure to Cl_2 vapor and liquid are negligible.

4. For each inhaled Cl_2 vapor Ct range, Table 4-22 summarizes the associated symptoms, Table 4-23 fully describes the associated Injury Profile for untreated personnel, and Table 4-24 describes the outcomes associated with medical treatment.

Table 4-22: Inhaled Cl_2 Vapor Ct Ranges

Inhaled Ct Range (mg-min/m^3)	Description
< 15	No observable effect in the majority of the population
15 – < 200	Mild shortness of breath; chest tightness; slight irritation of nose and throat; coughing; minor nasal congestion and runny nose; slight eye irritation; nausea; desire to vomit; headache; dizziness
200 – < 1000	Frank shortness of breath; some chest pain; difficulty breathing; more pronounced coughing and irritation of the throat; nasal and respiratory congestion with possible phlegm; severe eye irritation; vomiting
1000 – < 11000	Severe shortness of breath; marked chest pain; rapid and restricted breathing; intense coughing; tracheo-bronchitis; delayed onset of pulmonary edema and/or toxic pneumonitis or bronchio-pneumonia
≥ 11000	Extreme shortness of breath; decreased breath sounds; production of large amounts of frothy liquid; rapid onset of pulmonary edema; coma; death

Table 4-23: Inhaled Cl_2 Vapor Untreated Injury Profiles

Time Point (min)	Inhaled Ct Range			
	15 – < 200 mg-min/m^3	200 – < 1000 mg-min/m^3	1000 – < 11000 mg-min/m^3	≥ 11000 mg-min/m^3
1	1	2	2	3
120	1	2	2	4
135	1	2	2	4*
180	1	1	1	4
300	1	1	3	4
360	0	0	3	4
5760	0	0	0	4

* According to the default value for $T_{death\text{-}CN\text{-}SL4}$, death would be modeled at this point.

Table 4-24: Cl_2 Medical Treatment Outcome Reporting

Inhaled Ct Range (mg-min/m^3)	KIA	WIA	DOW	CONV	RTD
15 – < 200	0%	WIA(2^+ or 3^+) 0% WIA(1^+) Day 1: 100%	0%	0%	Day 2: 100%
200 – < 1000	0%	WIA(3^+) 0% WIA(1^+ or 2^+) Day 1: 100%	0%	0%	Day 2: 100%
1000 – < 11000	0%	Day 1: 100%	0%	0%	Day 5: 100%
≥ 11000	0%	Day 1: 100%	Day 2: 7%	0%	Day 8: 93%

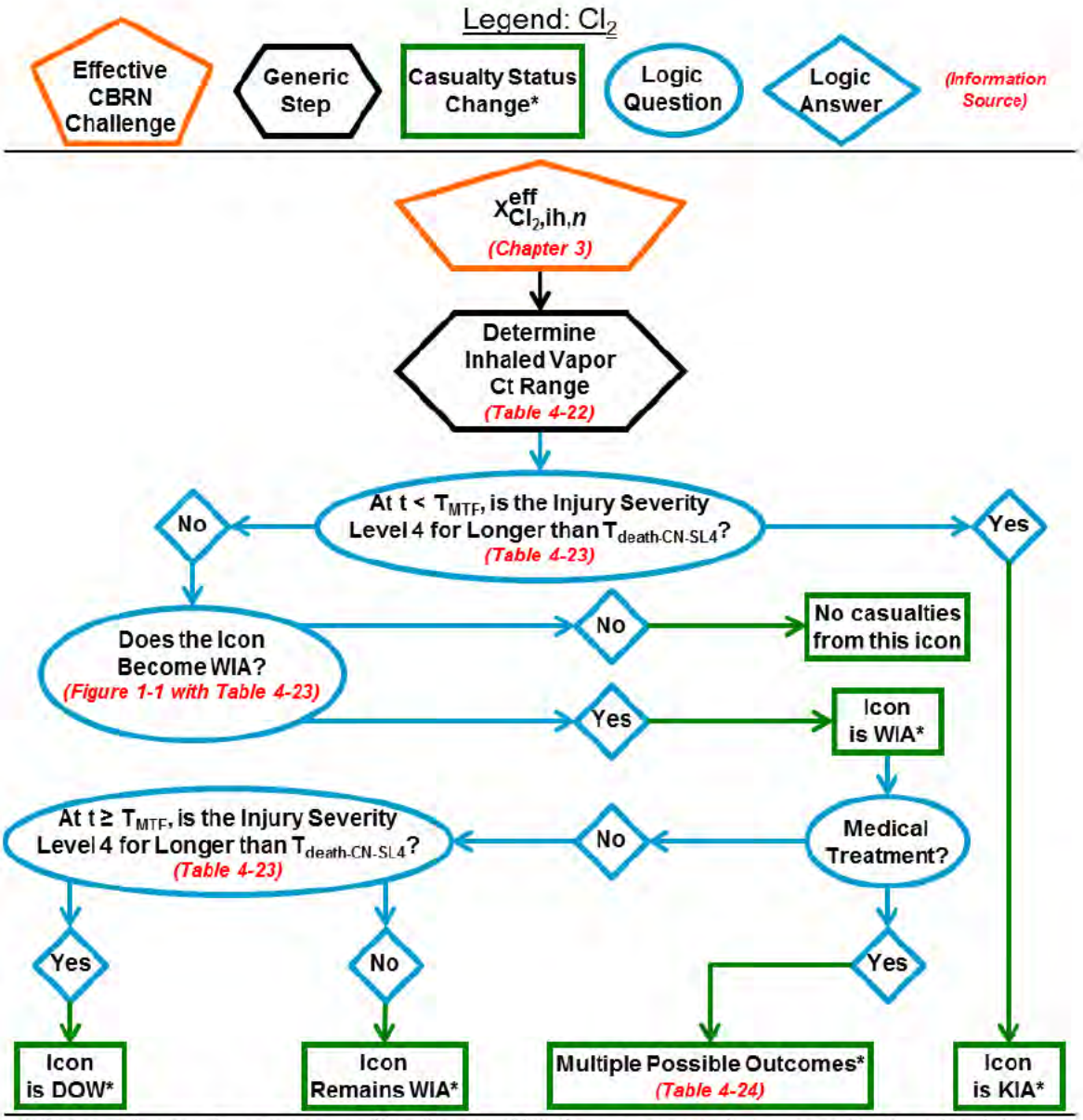


Figure 4-7: Human Response and Casualty Estimation Flowchart for Cl_2

4.2.7. AC

1. Figure 4-8 summarizes the human response and casualty estimation processes for AC.

2. Inhalation is the only AC challenge type considered. Each icon's inhaled Ct ($X^{eff}_{AC,ih,n}$) is estimated according to Chapter 3.

3. Assumption. Percutaneous exposure to AC vapor and liquid are negligible.

4. For each inhaled AC vapor Ct range, Table 4-25 summarizes the associated symptoms, Table 4-26 fully describes the associated Injury Profile for untreated personnel, and Table 4-27 describes the outcomes associated with medical treatment.

Table 4-25: Inhaled AC Vapor Ct Ranges

Inhaled Ct Range (mg-min/m^3)	Description
< 450	No observable effect in the majority of the population
450 – < 900	Upset stomach and nausea; fatigue and weakness; muscle twitching; ocular irritation; transient rapid breathing; mild shortness of breath; tight chest; excitement; anxiety; dizziness; headache
900 – < 1300	Episodes of vomiting; increased fatigue and weakness; muscle spasms; frank shortness of breath; difficult to breathe; drowsiness
1300 – < 2200	Severe generalized twitching with or without convulsions; breathing sporadically stops and starts; unconsciousness
≥ 2200	Convulsions; breathing stops completely; coma

Table 4-26: Inhaled AC Vapor Untreated Injury Profiles

Time Point (min)	Inhaled Ct Range			
	450 – < 900 mg-min/m^3	900 – < 1300 mg-min/m^3	1300 – < 2200 mg-min/m^3	≥ 2200 mg-min/m^3
1	1	2	3	4
10	1	1	2	4
15	1	1	2	4*
120	0	1	1	4
180	0	0	1	4
480	0	0	0	4

* According to the default value for $T_{death\text{-}CN\text{-}SL4}$, death would be modeled at this point.

Table 4-27: AC Medical Treatment Outcome Reporting

Inhaled Ct Range (mg-min/m^3)	KIA	WIA	DOW	CONV	RTD
450 – < 900	0%	WIA(2$^+$ or 3$^+$) 0% WIA(1$^+$) Day 1: 100%	0%	0%	Day 2: 100%
900 – < 1300	0%	WIA(3$^+$) 0% WIA(1$^+$ or 2$^+$) Day 1: 100%	0%	0%	Day 2: 100%
1300 – < 2200	0%	Day1: 100%	0%	0%	Day 2: 100%
≥ 2200*	Day 1: 100%	0%	0%	0%	0%
2200 – < 11000†	0%	Day 1: 100%	0%	0%	Day 2: 75% Day 3: 25%
≥ 11000†	Day 1: 100%	0%	0%	0%	0%

* This is the highest inhaled Ct range if the default methodology parameter values in Table 2-14 are used.

† If the user sets $T_{MTF} \leq T_{death\text{-}CN\text{-}SL4}$, these inhaled Ct ranges are used instead of the ≥ 2200 mg-min/m^3 range.

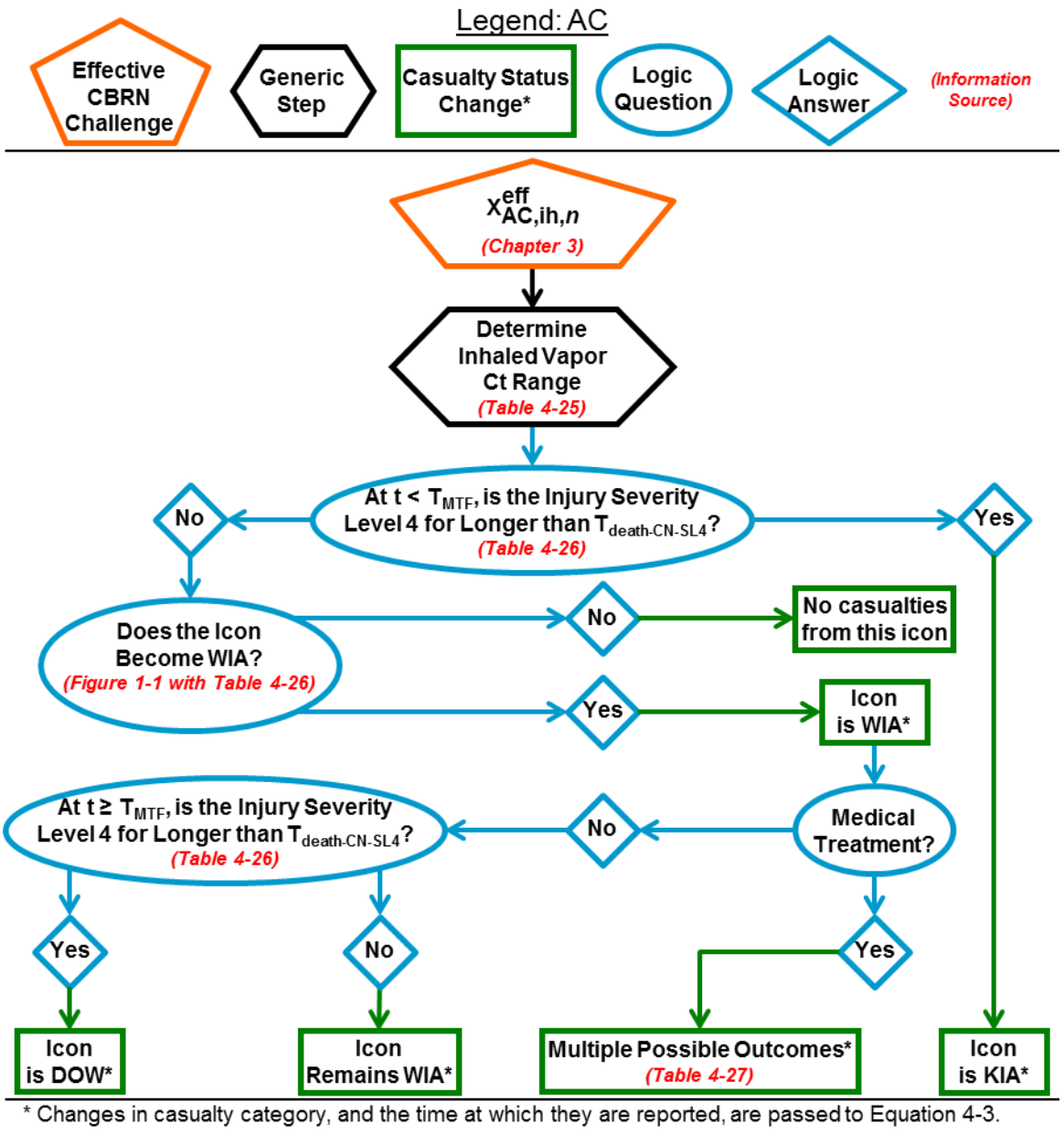


Figure 4-8: Human Response and Casualty Estimation Flowchart for AC

4.2.8. CK

1. Figure 4-9 summarizes the human response and casualty estimation processes for CK.

2. Inhalation is the only CK challenge type considered. Each icon's inhaled Ct ($X^{eff}_{CK,ih,n}$) and peak inhaled concentration ($X^{eff}_{CK,[ih],n}$) are estimated according to Chapter 3.

3. Assumption. Percutaneous exposure to CK vapor and liquid are negligible.

4. For each inhaled CK vapor Ct range, Table 4-28 summarizes the associated symptoms, Table 4-29 fully describes the associated Injury Profile for untreated personnel. Likewise, Table 4-30 and Table 4-31 describe the symptoms and Injury Profiles for each peak CK concentration range. Finally, Table 4-32 describes the outcomes associated with medical treatment.

Table 4-28: Inhaled CK Vapor Ct Ranges

Inhaled Ct Range (mg-min/m^3)	Description
< 800	No observable effect in the majority of the population
800 – < 1500	Upset stomach and nausea, fatigue and weakness, muscle twitching, ocular irritation, transient rapid breathing, mild shortness of breath, tight chest, excitement, anxiety, dizziness, headache
1500 – < 2300	Episodes of vomiting, increased fatigue and weakness, muscle spasms, frank shortness of breath, difficult to breathe, drowsiness
2300 – < 3800	Severe generalized twitching with or without convulsions, breathing sporadically stops and starts, unconsciousness
≥ 3800	Convulsions, delayed pulmonary edema, breathing stops completely, coma

Table 4-29: Inhaled CK Vapor Untreated Injury Profiles

Time Point (min)	Inhaled Ct Range			
	800 – < 1500 mg-min/m^3	1500 – < 2300 mg-min/m^3	2300 – < 3800 mg-min/m^3	≥ 3800 mg-min/m^3
1	1	2	3	4
10	1	1	2	4
15	1	1	2	4*
120	0	1	1	4
180	0	0	1	4
480	0	0	0	4

* According to the default value for $T_{death\text{-}CN\text{-}SL4}$, death would be modeled at this point.

Table 4-30: Peak Inhaled CK Vapor Concentration Ranges

Peak Inhaled Concentration Range (mg/m^3)	Description
< 1	No observable effect in the majority of the population
1 – < 20	Irritation of eyes, nose, and respiratory passages
≥ 20	Severe irritation of eyes, nose, and respiratory passages

Table 4-31: Peak Inhaled CK Vapor Concentration Untreated Injury Profiles

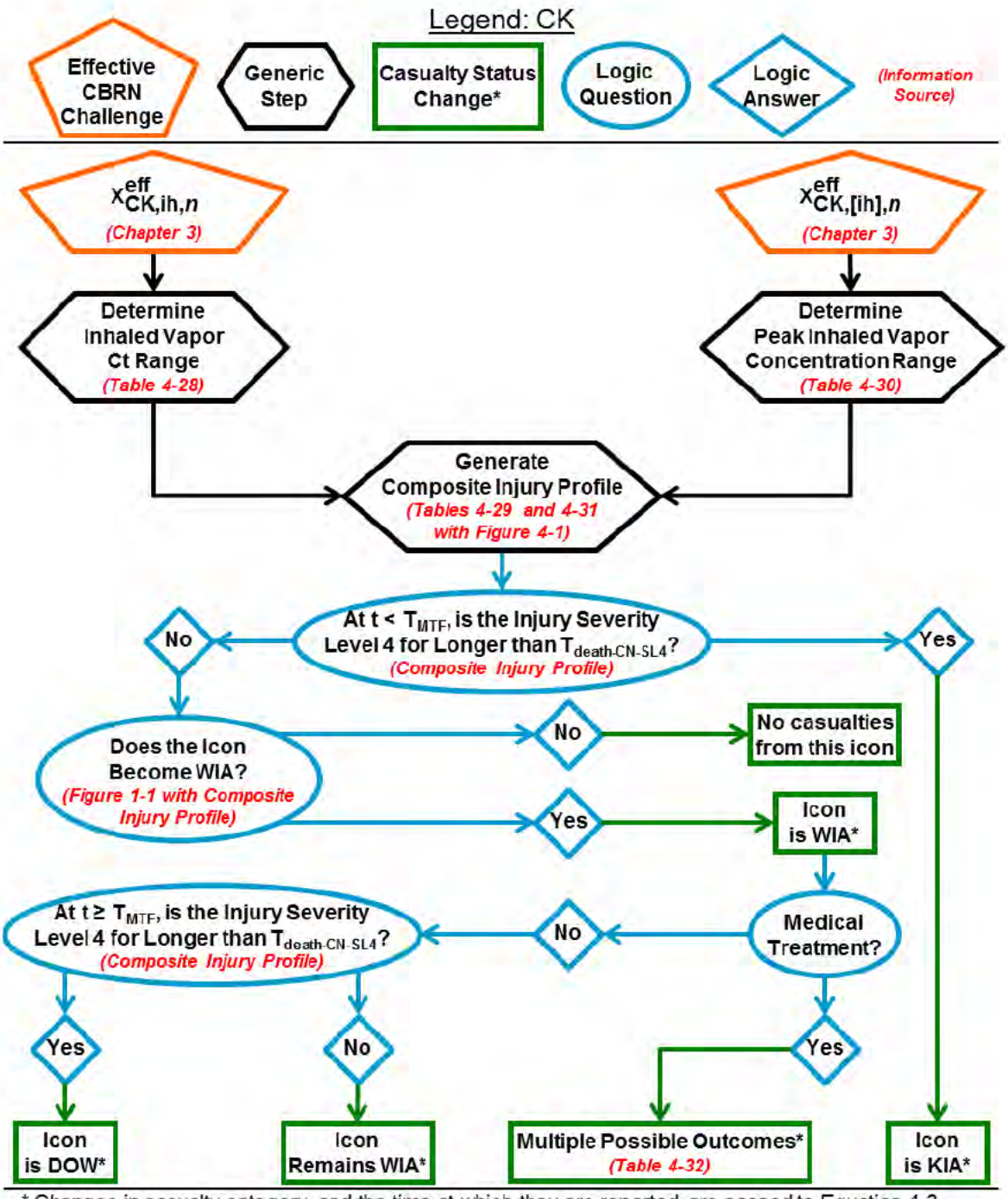
Time Point (min)	Peak Inhaled Concentration Range	
	1 – < 20 mg/m^3	≥ 20 mg/m^3
1	1	2
2	0	1
10	0	0

Table 4-32: CK Medical Treatment Outcome Reporting

Peak Inhaled Concentration Range (mg/m^3)	KIA	WIA	DOW	CONV	RTD
1 – < 20	0%	WIA(2^+ or 3^+) 0% WIA(1^+) Day 1: 100%	0%	0%	Day 2: 100%
≥ 20	0%	WIA(3^+) 0% WIA(1^+ or 2^+) Day 1: 100%	0%	0%	Day 2: 100%
Inhaled Ct Range (mg-min/m^3)	**KIA***	**WIA**	**DOW**	**CONV**	**RTD**
800 – < 1500	0%	WIA(2^+ or 3^+) 0% WIA(1^+) Day 1: 100%	0%	0%	Day 2: 100%
1500 – < 2300	Day 1: 100%	WIA(3^+) 0% WIA(1^+ or 2^+) Day 1: 100%	0%	0%	Day 2: 100%
2300 – < 3800	0%	Day 1: 100%	0%	0%	Day 2: 100%
≥ 3800*	Day 1: 100%	0%	0%	0%	0%
3800 – < 19000†	0%	Day 1: 100%	0%	0%	Day 2: 75% Day 3: 25%
≥ 19000†	Day 1: 100%	0%	0%	0%	0%

* This is the highest inhaled Ct range if the default methodology parameter values in Table 2-14 are used.

† If the user sets $T_{MTF} \leq T_{death\text{-}CN\text{-}SL4}$, these inhaled Ct ranges are used instead of the ≥ 3800 mg-min/m^3 range.



* Changes in casualty category, and the time at which they are reported, are passed to Equation 4-3.

Figure 4-9: Human Response and Casualty Estimation Flowchart for CK

4.2.9. H_2S

1. Figure 4-10 summarizes the human response and casualty estimation processes for H_2S.

2. Inhalation is the only H_2S challenge type considered. Each icon's inhaled Ct ($X^{eff}_{H2S,ih,n}$) is estimated according to Chapter 3.

3. Assumption. Percutaneous exposure to H_2S vapor and liquid are negligible.

4. For each inhaled H_2S vapor Ct range, Table 4-33 summarizes the associated symptoms, Table 4-34 fully describes the associated Injury Profile for untreated personnel, and Table 4-35 describes the outcomes associated with medical treatment.

Table 4-33: Inhaled H_2S Vapor Ct Ranges

Inhaled Ct Range (mg-min/m^3)	Description
< 200	No observable effect in the majority of the population
200 – < 1000	Ocular and respiratory irritation; throat hoarseness; nasal secretions; cough; mild dyspnea; nausea; weakness; chest pain; digestive upset; anxiety; headache; olfactory paralysis
1000 – < 1900	More pronounced ocular and respiratory irritation; cough; nonstop tearing and gritty feeling in eyes; sensitivity to light; frank shortness of breath; vomiting; increased fatigue and weakness; muscle spasms; drowsiness; pounding headache
1900 – < 2800	Severe lung irritation; blurry vision; intermittent apnea and wheezing breathing; rigidity in extremities; dry heaves; awful chest pain; amnesia for period of exposure; sudden unconsciousness or 'knockdown'
≥ 2800	Breathing completely stops; coughs up red colored mucus; coma; delayed pulmonary edema; cardiac arrest

Table 4-34: Inhaled H_2S Vapor Untreated Injury Profiles

Time Point (min)	Inhaled Ct Range			
	200 – < 1000 mg-min/m^3	1000 – < 1900 mg-min/m^3	1900 – < 2800 mg-min/m^3	≥ 2800 mg-min/m^3
1	1	2	3	4
5	0	2	3	4
10	0	2	2	4
15	0	2	2	4*
60	0	1	2	4
75	0	1	1	4
180	0	0	1	4
300	0	0	0	4

* According to the default value for $T_{death\text{-}CN\text{-}SL4}$, death would be modeled at this point.

Table 4-35: H_2S Medical Treatment Outcome Reporting

Inhaled Ct Range (mg-min/m^3)	KIA	WIA	DOW	CONV	RTD
200 – < 1000	0%	WIA(2^+ or 3^+) 0% WIA(1^+) Day 1: 100%	0%	0%	Day 2: 100%
1000 – < 1900	0%	WIA(3^+) 0% WIA(1^+ or 2^+) Day 1: 100%	0%	0%	Day 2: 100%
1900 – < 2800	0%	Day 1: 100%	0%	0%	Day 2: 100%
≥ 2800*	Day 1: 100%	0%	0%	0%	0%
2800 – < 5600†	0%	Day 1:100%	0%	0%	Day 15: 100%
≥ 5600†	Day 1: 100%	0%	0%	0%	0%

* This is the highest inhaled Ct range if the default methodology parameter values in Table 2-14 are used.

† If the user sets $T_{MTF} \leq T_{death\text{-}CN\text{-}SL4}$, these inhaled Ct ranges are used instead of the ≥ 2800 mg-min/m^3 range.

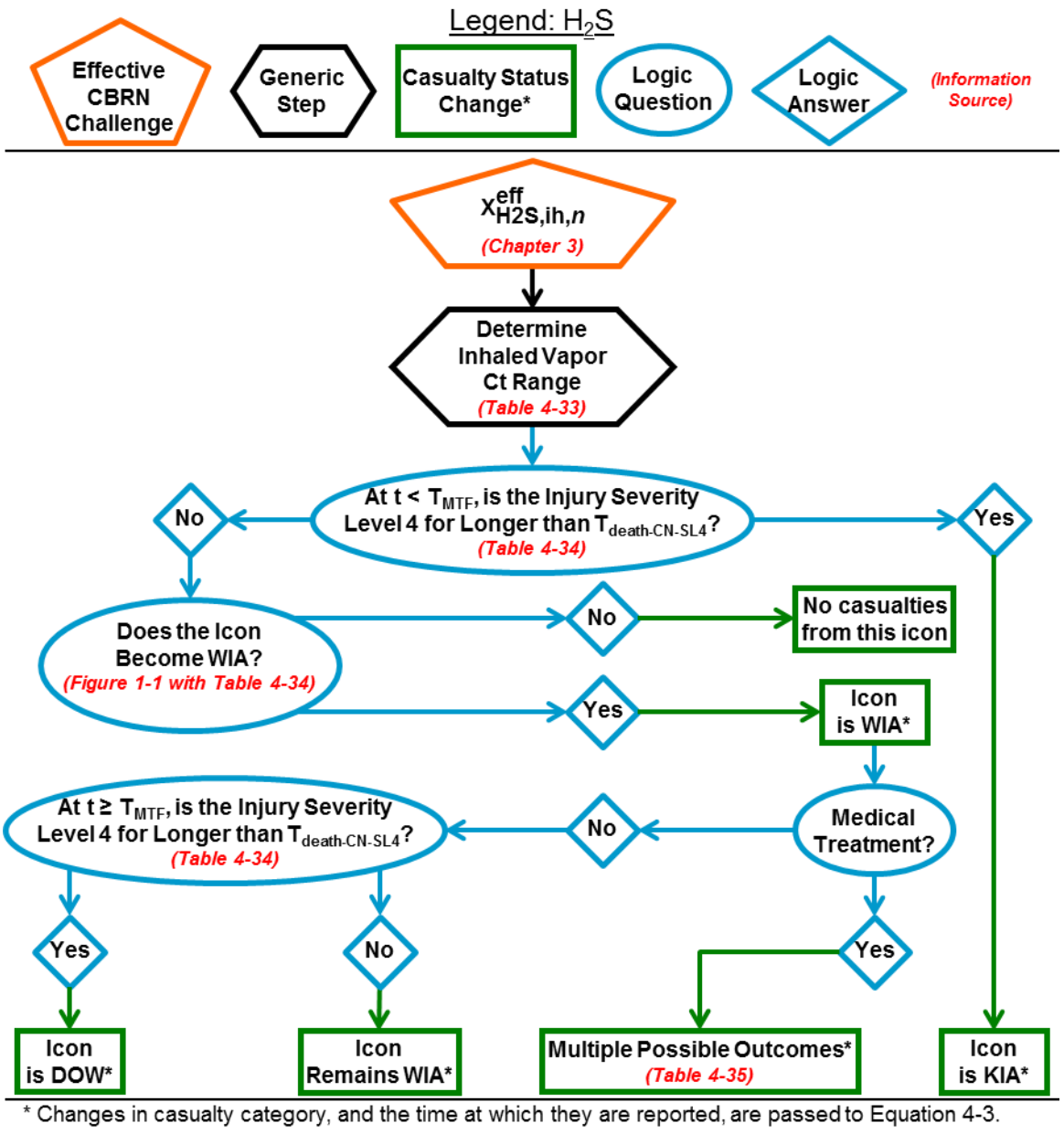


Figure 4-10: Human Response and Casualty Estimation Flowchart for H_2S

4.3. RADIOLOGICAL AGENT MODELS

This section begins with a discussion of assumptions and limitations that apply only to radiological agents. Following that are separate sections for RDDs and fallout that describe special methods for estimating Effective CBRN Challenge and provide a flowchart summarizing the process from Effective CBRN Challenge to casualty estimate. Following the RDD and fallout sections are two additional sections used for both RDDs and fallout:

a. Dose ranges, Injury Profiles, and medical treatment outcomes.

b. Special considerations for casualty estimation.

4.3.1. Assumptions and Limitations

1. Assumptions

a. Individuals will decontaminate the skin after exiting the radiation area.

b. Human response is independent of the source of exposure. For example, whole-body radiation Injury Profiles for radiological incidents are identical to those used for whole body radiation under the nuclear effects models.

c. Human response due to whole-body radiation dose and cutaneous radiation dose are independent of one another—the effects of each challenge type are modeled separately, and are only combined via a Composite Injury Profile.

d. For the purpose of estimating time to death due to whole-body radiation, each icon's dose rate is equal to the icon's total whole-body dose divided by the time over which the dose accumulated.

2. Limitations

a. Inhalation of radiological particles is neglected.

b. Dose protraction—a sufficiently low dose rate such that physiological recovery occurs simultaneously with the challenge—is only included as it pertains to determining whether a casualty will die; the Injury Profiles do not account for dose protraction.

4.3.2. RDDs

1. Figure 4-11 summarizes the human response and casualty estimation processes for RDDs.

2. Whole-body radiation (cloudshine and groundshine) and cutaneous radiation

(cloudshine, groundshine, and skin contamination) are the challenge types considered for RDDs.

a. Whole-body radiation.

1) Note that the cloudshine and groundshine components of whole-body radiation from RDDs are mixes of beta and gamma radiation. In calculating the APF, appropriate protection factors (from Table 2-7) must be chosen for each isotope, based on the type of radiation it *primarily* emits. For the isotopes included in Table 3-1, only ^{90}Sr is primarily a beta-emitter.

2) Each icon's isotope-specific absorbed whole-body dose from cloudshine from an RDD ($X^{eff}_{RDD,wb,cld,r,n}$) is estimated according to Chapter 3. Then, the isotope-specific doses are summed to determine the total absorbed whole-body dose from cloudshine from an RDD ($X^{eff}_{RDD,wb,cld,n}$), according to Equation 4-6.

$$X^{eff}_{RDD,wb,cld,n} = \sum_{r} X^{eff}_{RDD,wb,cld,r,n}\,, \tag{4-6}$$

where:

$X^{eff}_{RDD,wb,cld,n}$ is the absorbed whole-body cloudshine dose from an RDD for icon *n* [Gy], and

$X^{eff}_{RDD,wb,cld,r,n}$ is the absorbed whole-body cloudshine dose from the r^{th} radioisotope from an RDD for icon *n* [Gy] (derived from the output of a hazard prediction model).

3) Each icon's isotope-specific absorbed whole-body dose from groundshine from an RDD ($X^{eff}_{RDD,wb,grd,r,n}$) is estimated according to Chapter 3. Then, the isotope-specific doses are summed to determine the total absorbed whole-body dose from groundshine from an RDD ($X^{eff}_{RDD,wb,grd,n}$), according to Equation 4-7.

$$X^{eff}_{RDD,wb,grd,n} = \sum_{r} X^{eff}_{RDD,wb,grd,r,n}\,, \tag{4-7}$$

where:

$X^{eff}_{RDD,wb,grd,n}$ is the absorbed whole-body groundshine dose from an RDD for icon *n* [Gy], and

$X^{eff}_{RDD,wb,grd,r,n}$ is the absorbed whole-body groundshine dose from the r^{th} radioisotope from an RDD for icon *n* [Gy] (derived from the output of a hazard prediction model).

4) Finally, each icon's total absorbed whole-body dose from an RDD ($X^{eff}_{RDD,wb,n}$) is calculated according to Equation 4-8.

$$X^{eff}_{RDD,wb,n} = X^{eff}_{RDD,wb,cld,n} + X^{eff}_{RDD,wb,grd,n}, \quad (4\text{-}8)$$

where:

$X^{eff}_{RDD,wb,n}$ is the total absorbed whole-body dose from an RDD for icon *n* [Gy], and

the other terms are as previously defined.

b. Cutaneous radiation.

1) Note that the cloudshine and groundshine components of cutaneous radiation from RDDs can be a mix of beta and gamma radiation. In calculating the APF, appropriate protection factors (from Table 2-7) must be chosen for each isotope, based on the type of radiation it primarily emits. For the isotopes included in Table 3-1, only ^{90}Sr is primarily a beta-emitter. On the contrary, the skin contamination component is entirely from beta radiation.

2) Each icon's isotope-specific absorbed cutaneous dose from cloudshine from an RDD ($X^{eff}_{RDD,cut,cld,r,n}$) is estimated according to Chapter 3. Then, the isotope-specific doses are summed to determine the total absorbed cutaneous dose from cloudshine from an RDD ($X^{eff}_{RDD,cut,cld,n}$), according to Equation 4-9.

$$X^{eff}_{RDD,cut,cld,n} = \sum_{r} X^{eff}_{RDD,cut,cld,r,n}, \quad (4\text{-}9)$$

where:

$X^{eff}_{RDD,cut,cld,n}$ is the absorbed cutaneous cloudshine dose from an RDD for icon *n* [Gy], and

$X^{eff}_{RDD,cut,cld,r,n}$ is the absorbed cutaneous cloudshine dose from the r^{th} radioisotope from an RDD for icon *n* [Gy] (derived from the output of a hazard prediction model).

3) Each icon's isotope-specific absorbed cutaneous dose from groundshine from an RDD ($X^{eff}_{RDD,cut,grd,r,n}$) is estimated according to Chapter 3. Then, the isotope-specific doses are summed to determine the total absorbed cutaneous dose from groundshine from an RDD ($X^{eff}_{RDD,cut,grd,n}$) according to Equation 4-10.

$$X^{eff}_{RDD,wb,grd,n} = \sum_{r} X^{eff}_{RDD,cut,grd,r,n}\,, \tag{4-10}$$

where:

$X^{eff}_{RDD,cut,grd,n}$ is the absorbed cutaneous groundshine dose from an RDD for icon *n* [Gy], and

$X^{eff}_{RDD,cut,grd,r,n}$ is the absorbed cutaneous groundshine dose from the r^{th} radioisotope from an RDD for icon *n* [Gy] (derived from the output of a hazard prediction model).

4) Each icon's isotope-specific absorbed cutaneous dose from skin contamination from an RDD ($X^{eff}_{RDD,cut,s,r,n}$) is estimated according to Chapter 3, but with hazard prediction model output for groundshine as the data source for the challenge. Then, the isotope-specific doses are summed to determine the total absorbed cutaneous dose from skin contamination from an RDD ($X^{eff}_{RDD,cut,s,n}$) according to Equation 4-11.

$$X^{eff}_{RDD,cut,s,n} = \sum_{r} X^{eff}_{RDD,cut,s,r,n} \tag{4-11}$$

5) Finally, each icon's total cutaneous dose from an RDD ($X^{eff}_{RDD,cut,n}$) is estimated according to Equation 4-12.

$$X^{eff}_{RDD,cut,n} = X^{eff}_{RDD,cut,cld,n} + X^{eff}_{RDD,wb,cut,n} + X^{eff}_{RDD,cut,s,n}, \tag{4-12}$$

where:

$X^{eff}_{RDD,cut,n}$ is the total cutaneous dose for from an RDD icon *n* [Gy], and

the other terms are as previously defined.

3. Assumptions, limitations, and constraints.

a. Assumptions.

1) The activity deposited on the ground at the icon's location is equal to the activity deposited on the skin of each individual in the icon.

2) For calculations of dose due to groundshine, the activity concentration at the icon's location for the time period of interest is uniformly extended to infinity in all directions.

3) For the purpose of deriving the dose conversion factors in Table 3-1, absorbed dose (in units of gray) is equal to dose equivalent (in units of Sievert).

4) Cutaneous dose due to beta emitters contaminating *the clothing* is negligible[51] (contamination of the *skin* is counted).

b. Limitations.

1) Conventional casualties (i.e., from high explosives and fragmentation) that might occur as part of a RDD incident are ignored.

2) Gamma radiation due to skin contamination is ignored because it is typically only a few percent of the beta radiation dose.[52]

c. Constraint. Because the user is forced to choose either a gamma radiation protection factor *or* a beta radiation protection factor for each isotope, that protection factor is applied to all radiation emitted by that isotope.

[51] T. J. Cerveney, T. J. MacVittie, and R. W. Young, "Acute Radiation Syndrome in Humans," in *Warfare, Weaponry, and the Casualty*, ed. Richard I. Walker and T. J. Cerveney, *Textbooks of Military Medicine* (Falls Church, VA: OTSG, Department of the Army, 1996), 15–36, 21.

[52] International Atomic Energy Agency (IAEA), *Generic Procedures for a Radiological Emergency*, 104.

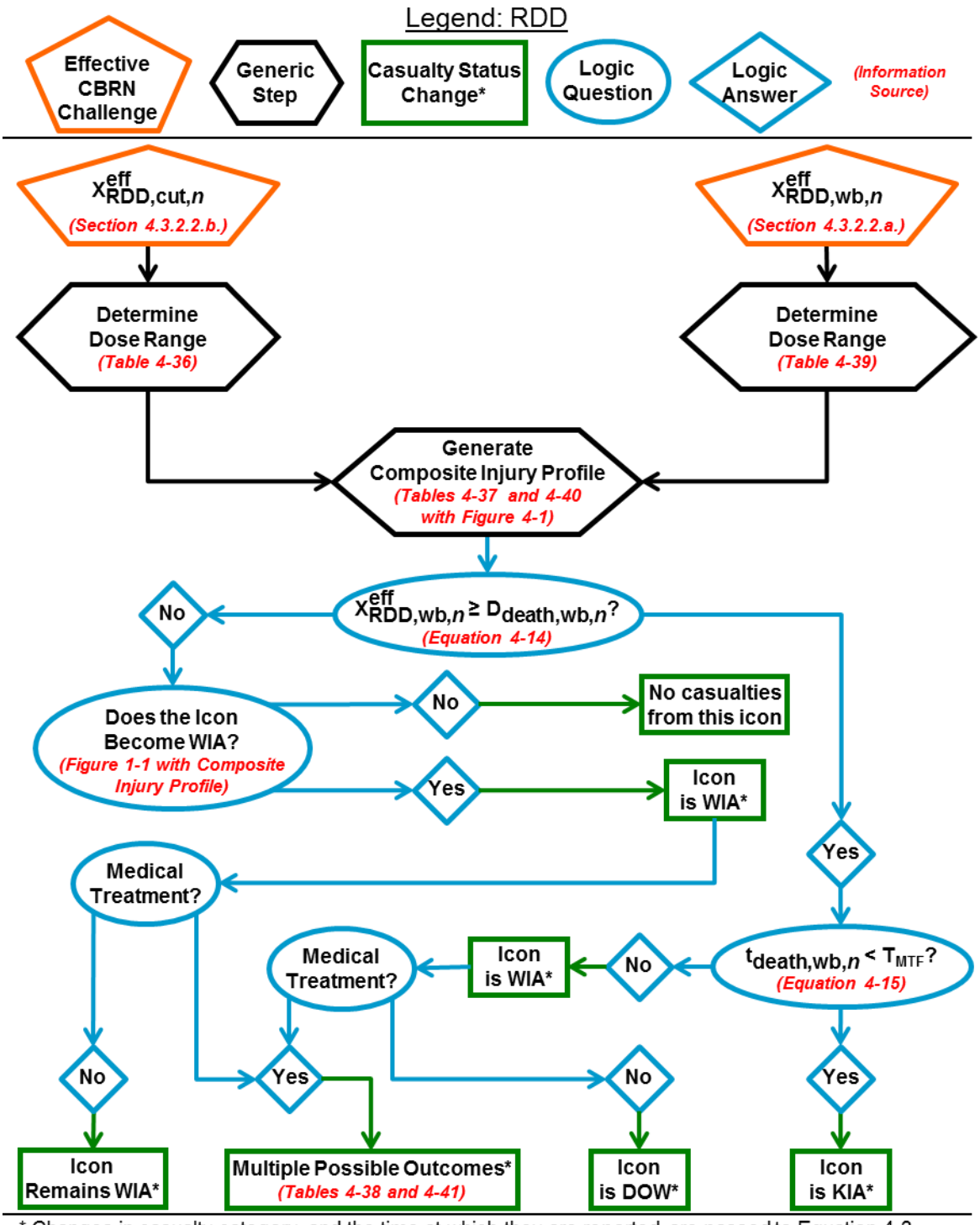


Figure 4-11: Human Response and Casualty Estimation Flowchart for RDDs

4.3.3. Fallout

1. Figure 4-12 summarizes the human response and casualty estimation processes for RDDs.

2. Whole-body radiation (from gamma radiation due to groundshine) and cutaneous radiation (from beta and gamma radiation due to groundshine and beta radiation from skin contamination) are the challenge types considered for fallout. A key difference for fallout, relative to RDDs, is that most hazard prediction models do not specify the distribution of radioisotopes in fallout. Thus, the equations below are not isotope-specific.

a. Whole-body radiation. Each icon's absorbed whole-body dose from fallout ($X^{eff}_{FO,wb,n}$) is estimated according to Chapter 3, based solely on input for gamma radiation due to groundshine from fallout (derived from a hazard prediction model).

b. Cutaneous radiation.

1) Each icon's absorbed cutaneous dose from gamma radiation due to groundshine from fallout ($X^{eff}_{FO,cut,grd\text{-}\gamma,n}$) is equal to its absorbed whole-body dose ($X^{eff}_{FO,wb,n}$).

2) Each icon's absorbed cutaneous dose from beta radiation due to groundshine from fallout ($X^{eff}_{FO,cut,grd\text{-}\beta,n}$) is estimated based on the gamma dose due to groundshine from fallout by means of a "gamma to beta" dose ratio. Thus, the Chapter 3 equations are fed input values for *gamma* groundshine from fallout (the same input used to calculate $X^{eff}_{FO,wb,n}$), but the APF should be based on *beta* radiation protection factors (see Table 2-7).

3) Each icon's absorbed cutaneous dose from beta radiation due to skin contamination from resuspension of fallout ($X^{eff}_{FO,cut,s,n}$) is estimated according to Chapter 3.

4) Finally, each icon's total cutaneous dose from fallout ($X^{eff}_{FO,cut,n}$) is estimated according to Equation 4-13.

$$X^{eff}_{FO,cut,n} = X^{eff}_{FO,cut,grd\text{-}\gamma,n} + X^{eff}_{FO,cut,grd\text{-}\beta,n} + X^{eff}_{FO,cut,s,n}, \quad (4\text{-}13)$$

where:

$X^{eff}_{FO,cut,n}$ is the total cutaneous dose from fallout for icon *n* [Gy], and

the other terms are as previously defined.

3. Assumptions, limitations, and constraints.

   a. Assumptions.

      1) Icons enter the radiation area only after all fallout has deposited on the ground.

      2) The deposition concentration on the skin is equal to the ground concentration at the icon's location.

   b. Limitations.

      1) Gamma radiation due to skin contamination is ignored because it is typically only a few percent of the beta radiation dose.[53]

      2) Isotope-specific dose calculations are not performed for fallout because most hazard prediction models do not specify the distribution of radioisotopes in fallout.

   c. Constraint. Only radiation from groundshine and skin contamination are considered.

[53] Ibid.

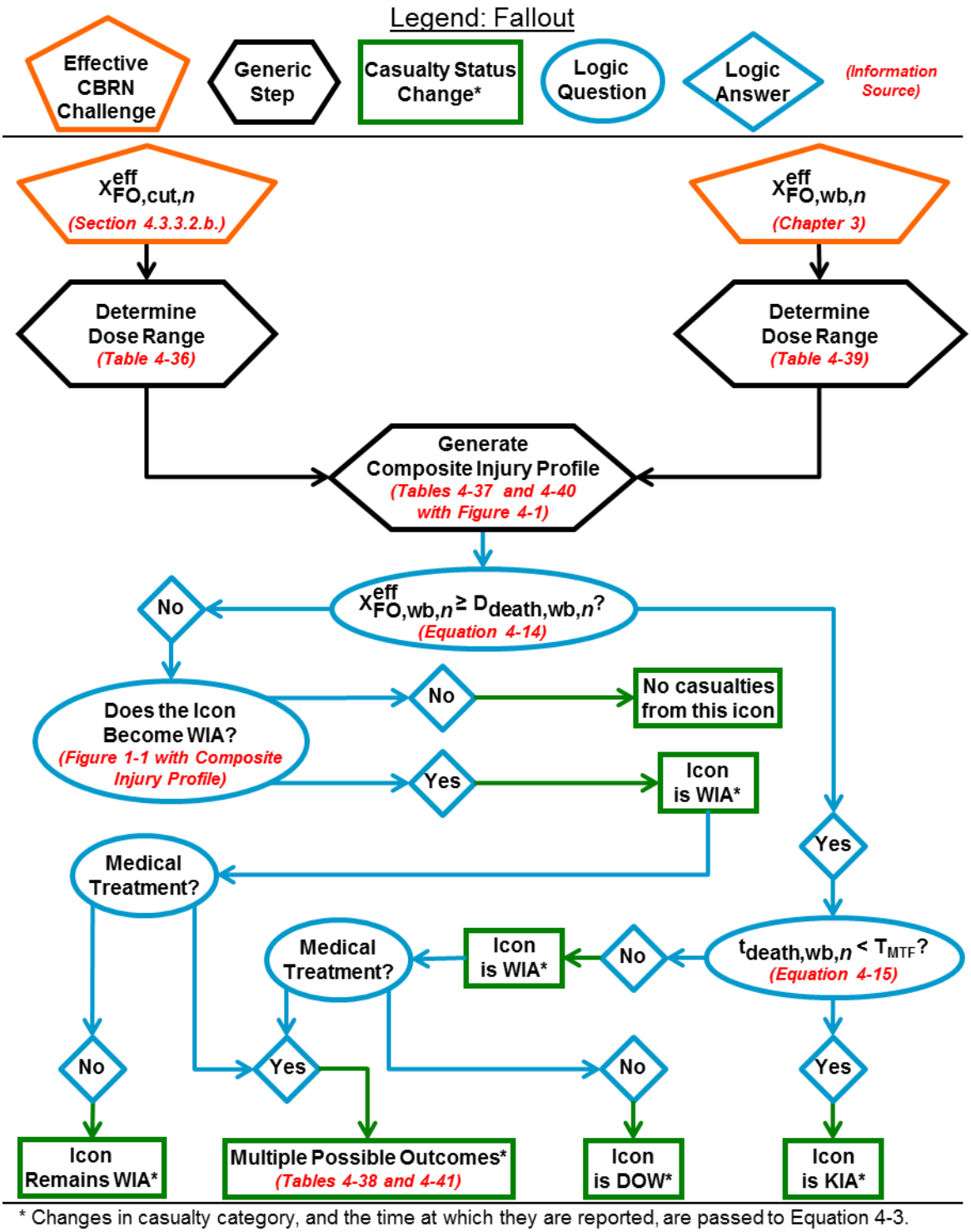


Figure 4-12: Human Response and Casualty Estimation Flowchart for Fallout

4.3.4. Dose Ranges, Injury Profiles, and Medical Treatment Outcomes

Because the dose ranges, Injury Profiles, and medical treatment outcomes for radiological challenges and injuries are independent of the challenge source, the tables presented below apply to both RDDs and fallout. Further, the whole-body tables also pertain to prompt radiation challenges from nuclear detonations.

Table 4-36: Cutaneous Radiation Dose Ranges

Dose Range (Gy)	Description
< 2	No observable effect in the majority of the population
2 – < 15	12 hours to 5 weeks post exposure: erythema, slight edema, possible increased pigmentation; 6 to 7 weeks post exposure: dry desquamation
15 – < 40	Immediate itching; 1 to 3 weeks post exposure: erythema, edema; 5 to 6 weeks post exposure: subcutaneous tissue edema, blisters, moist desquamation; late effects (> 10 weeks)
40 – < 550	Immediate pain, tingling for 1 to 2 days; 1 to 2 weeks post exposure: erythema, blisters, edema, pigmentation, erosions, ulceration, severe pain; severe late effects (> 10 weeks)
≥ 550	Immediate pain, tingling, swelling; 1 to 4 days post exposure: blisters, early ischemia, substantial pain; tissue necrosis within 2 weeks, substantial pain

Table 4-37: Cutaneous Radiation Untreated Injury Profiles

Time Point (hr)	Dose Range			
	2 – < 15 Gy	15 – < 40 Gy	40 – < 550 Gy	≥ 550 Gy
0.1	0	0	0	1
1	0	0	1	1
8	0	1	1	1
10	1	1	1	1
20	1	1	1	2
50	0	0	2	2
200	0	0	3	3

Table 4-38: Cutaneous Radiation Medical Treatment Outcome Reporting

Dose Range (Gy)	KIA	WIA	DOW	CONV	RTD
2 – < 15	0%	Day 1: 100%	0%	0%	Day 3: 100%
15 – < 40	0%	Day 1: 100%	0%	0%	Day 3: 100%
40 – < 550	0%	Day 1: 100%	0%	Day 3: 100%	0%
≥ 550	0%	Day 1: 100%	0%	Day 3: 100%	0%

Table 4-39: Whole-Body Radiation Dose Ranges

Dose Range (Gy)	Description
< 1.25	No observable effect in the majority of the population
1.25 – < 3	A slight decrease in white blood cell and platelet count with possible beginning symptoms of bone marrow damage; survival is > 90% unless there are other injuries
3 – < 4.5	Moderate to severe bone marrow damage occurs; lethality ranges from $LD_{5/60}$ to $LD_{50/60}$; these patients require greater than 30 days recovery, but other injuries would increase the injury severity and likelihood of death
4.5 – < 8.3	Severe bone marrow damage occurs; lethality ranges from $LD_{50/60}$ to $LD_{99/60}$; death occurs within 3.5 to 6 weeks with the radiation injury alone but is accelerated with other injuries; with other injuries death may occur within 2 weeks
≥ 8.3	Bone marrow pancytopenia and moderate intestinal damage occur including diarrhea; death is expected within 2 to 3 weeks; with other injuries death may occur within 2 weeks; at higher doses, combined gastrointestinal and bone marrow damage occur with hypotension and death is expected within 1 to 2.5 weeks or if other injuries are also present, within 6 days

Table 4-40: Whole-Body Radiation Untreated Injury Profiles

Time Point (hr)	Dose Range			
	1.25 – < 3 Gy	3 – < 4.5 Gy	4.5 – < 8.3 Gy	≥ 8.3 Gy
0.3	0	0	1	3
0.7	0	0	2	3
2	0	2	3	3
3	1	2	3	3
5	1	3	3	3
8	1	2	3	3
20	0	1	2	3
30	0	0	2	3
50	0	0	1	3
70	0	0	0	3
100	0	0	1	3
200	0	2	2	4
300	0	2	3	4
700	0	3	4	4

Table 4-41: Whole-Body Radiation Medical Treatment Outcome Reporting

Dose Range (Gy)	KIA	WIA	DOW*	CONV	RTD
1.25 – < 3	0%	WIA(2^+ or 3^+) 0% WIA(1^+) Day 1: 100%	0%	Day 2: 100%	0%
For Treatment Excluding G-CSF					
3 – < 6.8	0%	Day 1: 100%	0%	Day 37: 100%	0%
≥ 6.8	0%	Day 1: 100%	Rad: See Equation 4-14 Nuclear: 100%	100% of WIAs that do not DOW	0%
For Treatment Including G-CSF					
3 – < 8.5	0%	Day 1: 100%	0%	Day 37: 100%	0%
≥ 8.5	0%	Day 1: 100%	Rad: See Equation 4-14 Nuclear: 100%	100% of WIAs that do not DOW	0%

* Equations 4-15 and 4-17 estimate time of death for radiological and nuclear DOWs, respectively.

4.3.5. Special Considerations for Casualty Estimation

1. If an icon's total absorbed whole-body dose from an RDD or fallout ($X^{eff}_{RDD/FO,wb,n}$) is above a certain threshold dose, labeled $D_{death,wb,n}$, the individuals in that icon are estimated to die if no medical treatment is provided (time of death is discussed below). The threshold dose depends on the dose rate, as described in Equation 4-14 (an empirical equation).[54]

$$D_{death,wb,n} = \frac{LD_{50,MT}}{-0.2351 \cdot 0.8946^{\left(\frac{X^{eff}_{RDD/FO,wb,n}}{Dur_n}\right)} \cdot \left(\frac{X^{eff}_{RDD/FO,wb,n}}{Dur_n}\right)^{-0.2876} + 0.9947}, \quad (4\text{-}14)$$

where:

$D_{death,wb,n}$ is the threshold dose above which individuals in icon *n* are estimated to die [Gy],

$LD_{50,MT}$ is the LD_{50} for an instantaneous challenge [gray], which is a function of whether medical treatment is provided, and if so, whether granulocyte colony-stimulating factor (G-CSF) is part of that treatment (see Table 4-42),

[54] This equation is derived from data presented in Gene E. McClellan, David J. Crary, and Darren R. Oldson, *Approximating the Probability of Mortality Due to Protracted Radiation Exposures*, ARA-TR-08-SEASSP-17176-1 (Arlington, VA: Applied Research Associates, Inc., 2008), 7, Table 1.

$X^{eff}_{RDD/FO,wb,n}$ is the total absorbed whole-body dose from an RDD or from fallout for icon *n* [Gy], and

Dur_n is the duration of exposure for Icon *n* [hr] (derived from the hazard prediction model).

Table 4-42: Whole-Body Radiation LD_{50} for Instantaneous Challenges

Situation	LD_{50} [gray]
No medical treatment	4.5
Medical treatment excluding G-CSF	6.8
Medical treatment including G-CSF	8.5

2. For icons with total absorbed whole-body dose above $D_{death,wb,n}$, the time to death is empirically estimated by an empirical equation, Equation 4-15.[55]

$$T_{death,wb,n} = \frac{4.1 \cdot 10^6}{24} \cdot (X^{eff}_{RDD/FO,wb,n} \cdot 100)^{-1.3}, \quad (4\text{-}15)$$

where:

$T_{death,wb,n}$ is the time between the end of exposure and death for individuals at icon *n* [days], and

$X^{eff}_{RDD/FO,wb,n}$ is the total absorbed whole-body dose from an RDD or from fallout for icon *n* [Gy].

4.4. NUCLEAR EFFECTS MODELS

1. A nuclear detonation may result in four challenges for each icon. Immediately after the detonation, icons may receive whole-body radiation, blast, and thermal challenges; the modeling of these "prompt" challenges is described in this section. Later, icons may receive a fallout challenge; the modeling of this delayed effect was discussed in section 4.3.

2. This section begins with a discussion of assumptions and limitations that apply only to prompt nuclear effects. Following that are separate sections on each prompt nuclear effect that describe special methods for estimating Effective CBRN Challenge and provide a flowchart summarizing the process from Effective CBRN

[55] John A. Northrop, ed. *Handbook of Nuclear Weapon Effects: Calculational Tools Abstracted from Dswa's Effects Manual One (Em-1)* (Alexandria, VA: Defense Special Weapons Agency, 1996), Figures 14.17 and 14.18.

Challenge to casualty estimate. The final subsection briefly discusses how the methodology accounts for the combined effects of nuclear weapons.

4.4.1. Assumptions and Limitations

1. Assumptions.

   a. Human response is independent of the source of exposure. For example, whole-body radiation Injury Profiles for radiological incidents are identical to those used for whole body radiation under the nuclear effects models.

   b. The entire challenge occurs immediately following the detonation (consistent with fallout being modeled separately, as described in section 4.3.3).

2. Limitation. With the exception of the few considerations described in section 4.4.5, the combined effects of prompt nuclear injuries are not considered; initial radiation, blast, and burn injuries are considered separately.

4.4.2. Initial Whole-body Radiation

1. Figure 4-13 summarizes the human response and casualty estimation processes for initial whole-body radiation from a nuclear detonation.

2. Initial whole-body radiation from a nuclear detonation comprises two components: neutron radiation and gamma radiation.

   a. Each icon's absorbed whole-body dose from neutron radiation ($X^{eff}_{nuc,wb,n^0,n}$) is estimated according to Chapter 3.

   b. Each icon's absorbed whole-body dose from gamma radiation ($X^{eff}_{nuc,wb,\gamma,n}$) is estimated according to Chapter 3.

   c. Finally, each icon's total absorbed whole-body dose from initial radiation from a nuclear detonation ($X^{eff}_{nuc,wb,n}$) is calculated according to Equation 4-16.

$$X^{eff}_{nuc,wb,n} = X^{eff}_{nuc,wb,n^0,n} + X^{eff}_{nuc,wb,\gamma,n}, \quad (4\text{-}16)$$

   where:

   $X^{eff}_{nuc,wb,n}$ is the total absorbed whole-body dose from initial radiation from a nuclear detonation for icon *n* [Gy], and

   the other terms are as previously defined.

3. Assumption. The relative biological effectiveness (RBE) for neutron/gamma radiation is 1.

4. Special consideration for initial whole-body radiation casualty estimation.

   a. If an icon's total absorbed whole-body dose from prompt nuclear radiation ($X^{eff}_{nuc,wb,n}$) is greater than 4.5 Gy, the individuals in that icon are estimated to die if no treatment is provided. If treatment is provided, the medical treatment outcomes table (Table 4-41) is used.

   b. Time to death is determined by an empirical equation, Equation 4-17.[56]

$$T_{death,wb,n} = \frac{4.1 \cdot 10^6}{24} \cdot (X^{eff}_{nuc,wb,n} \cdot 100)^{-1.3}, \qquad (4\text{-}17)$$

   where:

   $T_{death,wb,n}$ is the time between the end of exposure and death for individuals at icon *n* [days],

   $X^{eff}_{nuc,wb,n}$ is the total absorbed whole-body dose from prompt nuclear radiation for icon *n* [Gy].

5. For each total absorbed whole-body dose range, the symptoms, Injury Profile, and medical outcomes are the same as those described for whole-body radiation doses from RDDs or fallout. Thus, Table 4-39 summarizes the associated symptoms, Table 4-40 fully describes the associated Injury Profile for untreated personnel, and Table 4-41 describes the outcomes associated with medical treatment.

[56] Ibid.

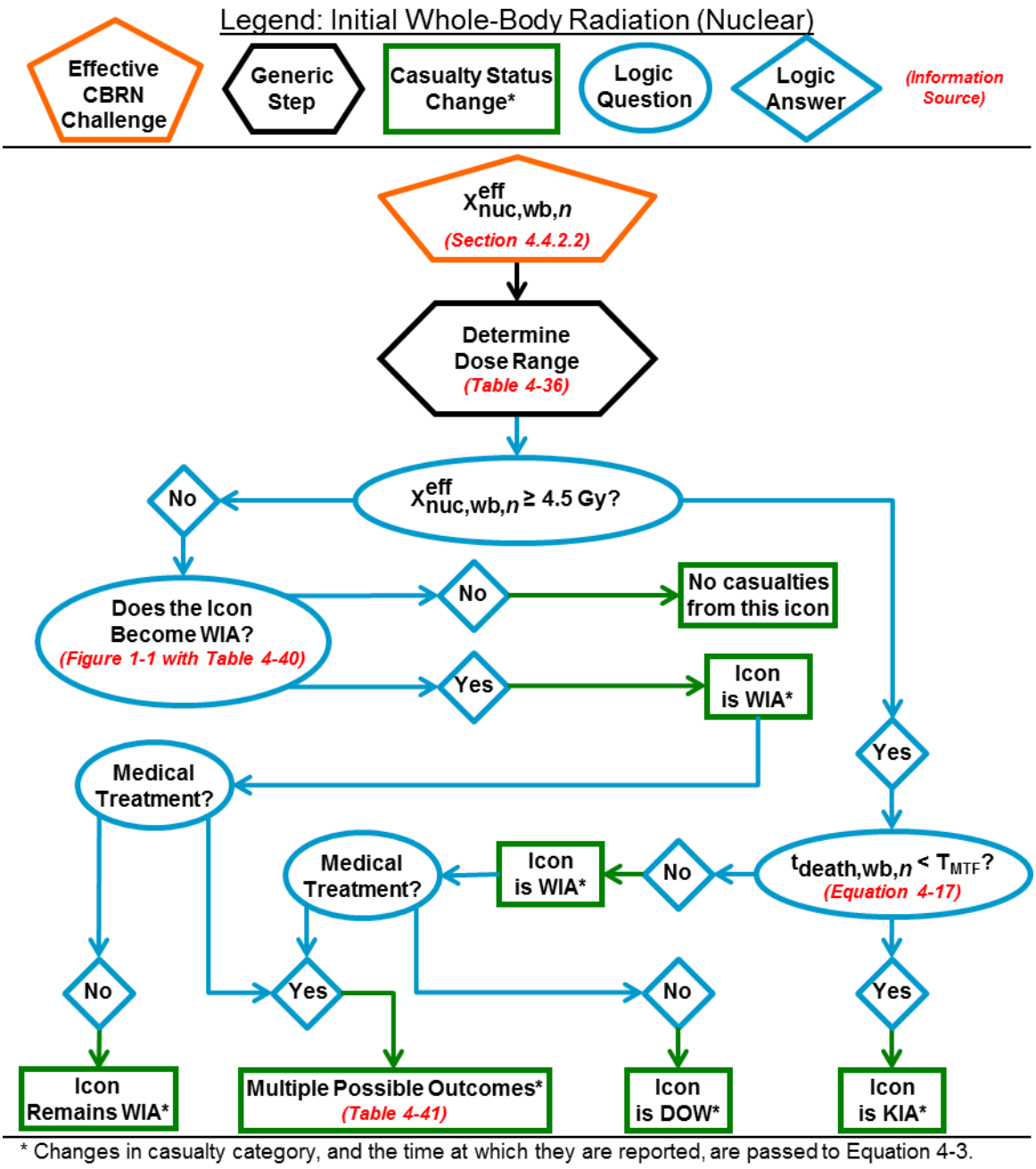


Figure 4-13: Human Response and Casualty Estimation Flowchart for Initial Whole-Body Radiation From a Nuclear Detonation

4.4.3. Blast

1. Figure 4-14 summarizes the human response and casualty estimation processes for nuclear blast.

2. Each icon's primary nuclear blast insult ($X^{eff}_{nuc,blast,n}$) is estimated according to Chapter 3.

3. Limitations and constraints.

   a. Limitation. Secondary effects (missiling) are not included in any way.

   b. Constraints.

      1) The blast model primarily accounts for primary blast effects (static overpressure, or barotrauma).

      2) It also uses the blast static overpressure as an index for partially accounting for tertiary (whole-body translation and decelerative tumbling) effects; additional KIAs are estimated as a function of weapon yield.

4. Special consideration for nuclear blast casualty estimation. A threshold blast insult ($I_{death,blast}$), above which icons *not occupying a vehicle or shelter* are estimated to be KIA, is used to account for lethal tertiary effects. Table 4-43 lists the specific insult threshold as a function of weapon yield.

Table 4-43: Blast Static Overpressure Thresholds for Declaration of KIA Due to Tertiary Nuclear Blast Effects

Weapon Yield [kT]	Insult Threshold ($I_{death,blast}$) [kPa]	Weapon Yield [kT]	Insult Threshold ($I_{death,blast}$) [kPa]
1	689	20	257
2	571	30	233
3	501	40	217
4	452	50	204
5	414	60	194
6	383	70	185
7	357	80	178
8	334	90	171
9	314	100	165
10	296		

* Derived from M. K. Drake et al., *An Interim Report on Collateral Damage* DNA 4734Z (La Jolla, CA: Science Applications, Inc., October 1978), 5-94.

5. For each primary nuclear blast insult range, Table 4-44 summarizes the associated symptoms, Table 4-45 fully describes the associated Injury Profile for untreated personnel, and Table 4-46 describes the outcomes associated with

medical treatment.

Table 4-44: Primary Nuclear Blast Insult Ranges

Insult Range (kPa)	Description
< 50	No observable effect in the majority of the population
50 – < 140	Eardrum rupture in 50%; threshold lung damage; threshold gastrointestinal damage
140 – < 240	Burdening level lung damage in 50%; burdening level tympanic membrane rupture in 90%
240 – < 290	Burdening level lung damage in 90%; lethality in 10%
≥ 290	Lethality in ≥ 50%

Table 4-45: Primary Nuclear Blast Untreated Injury Profiles

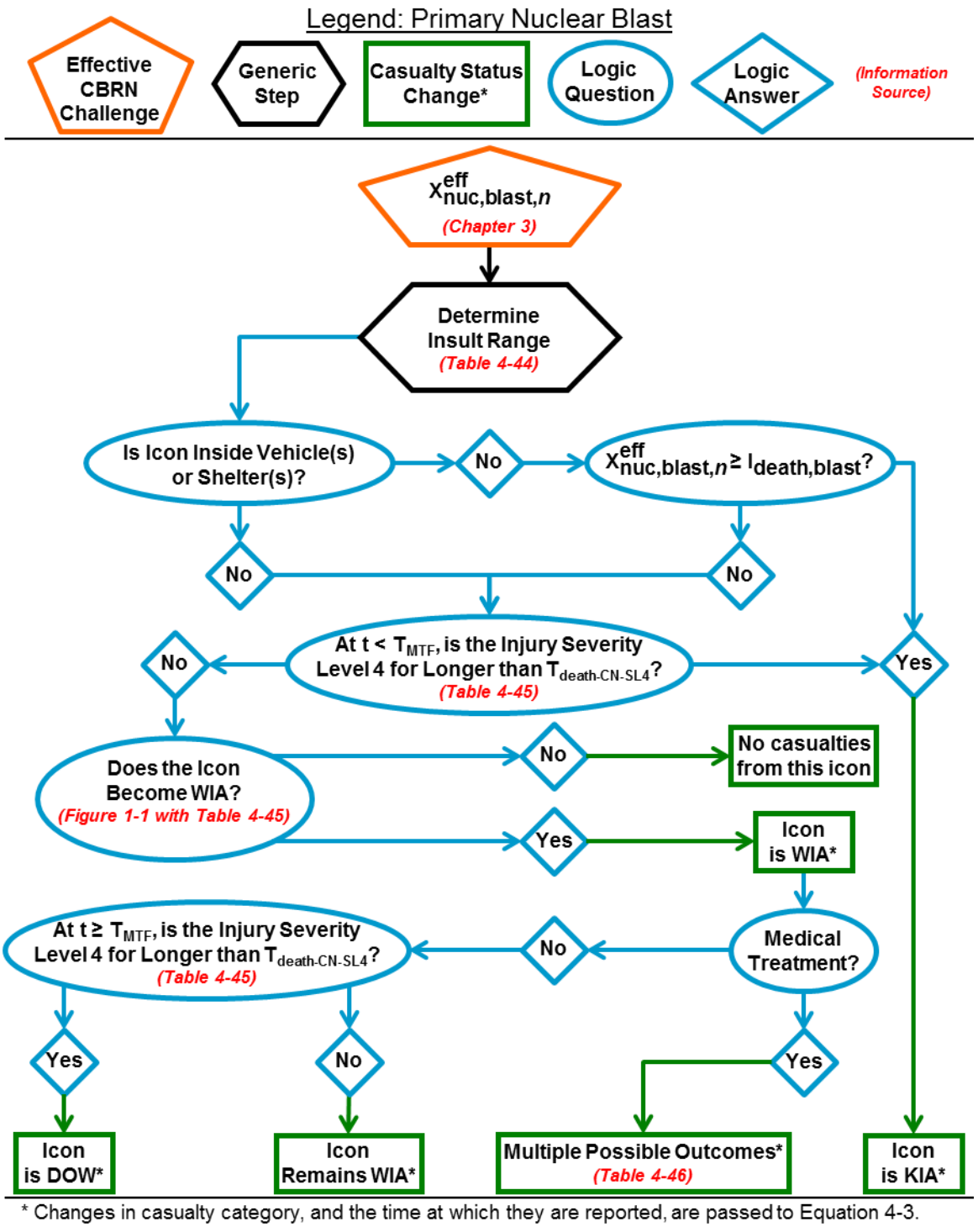
Time Point (hr)	Insult Range			
	50 – < 140 kPa	140 – < 240 kPa	240 – < 290 kPa	≥ 290 kPa
0.25	2	3	3	4*
30	2	2	3	4
40	1	2	3	4
200	0	1	3	4
300	0	1	2	4
400	0	0	1	4
700	0	0	0	4

* According to the default value for $T_{death\text{-}CN\text{-}SL4}$, death would be modeled at this point.

Table 4-46: Primary Nuclear Blast Medical Treatment Outcome Reporting

Insult Range (kPa)	KIA	WIA	DOW	CONV	RTD
50 – < 140	0%	WIA(3^+) 0% WIA(1^+ or 2^+) Day 1: 100%	0%	0%	Day 8: 100%
140 – < 240	0%	Day 1: 100%	0%	0%	Day 25: 100%
240 – < 290	0%	Day 1: 100%	0%	0%	Day 36: 100%
≥ 290	0%	Day 1: 100%	Day 2: 23%	Day 36: 77%	0%

Note: since this table applies to *primary* blast injuries, modeling of lethal tertiary effects as described in section 4.4.3.4. is not affected by the availability of medical treatment.



* Changes in casualty category, and the time at which they are reported, are passed to Equation 4-3.

Figure 4-14: Human Response and Casualty Estimation Flowchart for Primary Nuclear Blast

4.4.4. Thermal Fluence

1. Figure 4-15 summarizes the human response and casualty estimation processes for thermal fluence from a nuclear detonation.

2. Each *individual's* insult due to thermal fluence ($X^{eff}_{nuc,thermal,n}$), expressed as percent body surface area with second or third degree burns (%BSA), is estimated according to the following unique algorithm used only for this specific application; Chapter 3 is *not* used to estimate $X^{eff}_{nuc,thermal,n}$.

a. First, for each icon, the number of individuals actually challenged by thermal fluence is estimated using Equation 4-18; if the icon is occupying a vehicle or shelter when the nuclear weapon detonates, only a fraction of the personnel in the icon is estimated to be challenged by thermal fluence.

$$i_{nuc,therm,n} = P_{trans} \cdot i_n, \qquad (4\text{-}18)$$

where:

$i_{nuc,therm,n}$ is the number of individuals in icon *n* that are actually challenged by thermal fluence (note: this value is passed to Equation instead of i_n),

P_{trans} is the thermal transmission probability for the specific vehicle or shelter the icon occupies (see Table 4-47), and

i_n is the number of individuals in icon *n*.

Table 4-47: Recommended Thermal Transmission Probabilities for Various Vehicle/Shelter Types

Vehicle/Shelter Thermal Class	Thermal Transmission Probability (P_{trans})*	
	Unwarned	Warned
None	1.00	1.00
Armored Personnel Carrier – Closed	0.00	0.00
Armored Personnel Carrier – Moving	0.50	0.00
Armored Personnel Carrier – Open	1.00	0.00
Earth Shelter	0.75	0.05
Exposed/Dismounted	1.00	1.00
Foxhole	1.00	0.05
Light Truck	0.90	0.50
Masonry Building – Few Windows	0.10	0.00
Masonry Building – Many Windows	0.25	0.00
Multi-Story Brick Building	0.25	0.00
Panel Van	0.05	0.00
Semi-Trailer Van	0.90	0.90
Tank – Defense	0.50	0.00
Tank – Movement	0.75	0.00
Tank – Offense	0.00	0.00
Tent	0.25	0.25
Truck	0.90	0.90
Truck in Revetment	0.50	0.05
Wood Frame Building	0.25	0.05

* These values are notional.

b. Second, Equation 4-19 is used to estimate the thermal fluence insult ($X^{eff}_{nuc,thermal,n}$) to the individuals within the icon that are challenged.[57] Equation 4-19 is dependent on the CBRN Challenge and thermal fluence thresholds that vary by uniform/IPE. The user may instead provide specific values of $X^{eff}_{nuc,thermal,n}$ for each icon.

$$X^{eff}_{nuc,thermal,n} = \frac{\arccos\left(\frac{Q_{T,uniform,n}}{X_{nuc,thermal,n}}\right)}{\pi} \cdot P\%_{uniform,n} + \frac{\arccos\left(\frac{Q_{T,skin}}{X_{nuc,thermal,n}}\right)}{\pi} \cdot P\%_{skin,n}, \quad (4\text{-}19)$$

where:

$X^{eff}_{nuc,thermal,n}$ is the thermal fluence insult for icon *n* [%BSA],

[57] Sheldon G. Levin, *The Effect of Combined Injuries from a Nuclear Detonation on Soldier Performance* (Espanola, NM: Technical Southwest, Inc., 1993), 24.

arccos is the arccosine,[58] which must be expressed in radians (not degrees),

$Q_{T,uniform}$ is the thermal fluence threshold for a partial-thickness (second degree) burn for the uniform type worn by icon *n*[59] [kJ/m^2] (Table 4-48),

$Q_{T,skin}$ is the thermal fluence threshold value for bare skin for a partial-thickness (second degree) burn [kJ/m^2] (Table 4-48),

$X_{nuc,thermal,n}$ is the thermal fluence that challenges icon *n* [kJ/m^2] (derived from the output of a hazard prediction model),

$P\%_{uniform,n}$ is the percentage of the body covered by the uniform for icon *n*,[60] and

$P\%_{skin,n}$ is the percentage of the body that is bare for icon *n*.

Table 4-48: Thermal Fluence Threshold Values for Partial-Thickness (Second Degree) Burns for Various Uniform Types

Uniform/Clothing	Threshold Thermal Fluence (Q_T) [kJ/m^2]
Bare Skin	109
Battledress Uniform (BDU) + T-shirt	310
BDU + T-shirt + Airspace†	630
Battledress Overgarment (BDO)	420
BDO + Airspace†	670
BDO + BDU + T-shirt	1300
BDO + BDU + T-shirt + Airspace†	2010

* Anthony J. Baba et al., *Incidence of Skin Burns under Contemporary Army Uniforms Exposed to Thermal Radiation from Simulated Nuclear Fireballs*, HDL-TR-2084 (Adelphi, MD: U.S. Army Laboratory Command, Harry Diamond Laboratories, December 1986), 24, Table 4 and Levin, *Effect of Combined Injuries*, 24.

† Airspace indicates looser clothing (i.e., clothing with airspace between the body and the garment), as opposed to fitted clothing.

3. Assumptions, limitations, and constraints.

a. Assumptions.

[58] Note that the arccosine is undefined if the argument is > 1. Thus, for thermal insults ($X^{term}_{nuc,thermal,n}$) below the relevant threshold ($Q_{T,uniform}$ or $Q_{T,skin}$), the corresponding arccosine term becomes zero. If both terms become zero for this reason, then the icon is not injured by thermal effects.

[59] Typically assumed to be "BDU+T-shirt."

[60] Typically assumed to be 88% for unwarned cases and 100% for warned cases.

1) Thermal fluence resulting from a nuclear detonation is translated to a percentage of body surface area burned, with the percentage being dependent on the type of uniform or clothing worn and the fit of the garment.

2) The Injury Profile and associated casualty category changes are independent of which body part(s) suffer(s) burns.

b. Limitations.

1) The effects of thermal flash (such as flash blindness) are ignored.

2) The percentage of body surface area burned excludes first degree (epidermal or surface) burns.

c. Constraint. The percentage of body surface area burned includes partial-thickness (2nd degree) and full-thickness (3rd degree) burns.

4. For each thermal fluence insult range, Table 4-49 summarizes the associated symptoms, Table 4-50 fully describes the associated Injury Profile for untreated personnel, and Table 4-51 describes the outcomes associated with medical treatment.

Table 4-49: Thermal Fluence Insult Ranges

Insult Range (%BSA)	Description*
< 1	No observable effect in the majority of the population†
1 – < 10	1st, 2nd and possible 3rd degree burns; electrolyte imbalance; pain
10 – < 20	Upper GI discomfort; 1st, 2nd and possible 3rd degree burns; electrolyte imbalance; increased pain
20 – < 30	Upper GI discomfort; 1st, 2nd and possible 3rd degree burns; fluid loss; decreased renal blood flow; compromise of the immune system; pain; lethality in 10%
≥ 30	Upper GI discomfort; 2nd and 3rd degree burns; hypovolemia; decreased renal blood flow; shock resulting from blood pressure decrease; cardiac distress; toxemia; multiple organ failure; lethality in ≥ 50%

* Estimation of burn lethality is approximate.
† < 1 %BSA may include a larger area of 1st degree burns.

Table 4-50: Thermal Fluence Untreated Injury Profiles

Time Point (hr)	Insult Range			
	1 – < 10 %BSA	10 – < 20 %BSA	20 – < 30 %BSA	≥ 30 %BSA
0.1	1	2	3	3
20	1	2	3	4*
50	2	2	3	4
336	0	1	3	4

* According to the default value for $T_{death\text{-}CN\text{-}SL4}$, death would be modeled at this point.

Table 4-51: Thermal Fluence Medical Treatment Outcomes

Insult Range (%BSA)	KIA	WIA	DOW	CONV	RTD
1 – < 15	0%	WIA(3^+) 0% WIA(2^+) Day 2: 100% WIA(1^+) Day 1: 100%	0%	0%	Day 22: 100%
15 – < 30	0%	WIA(3^+) 0% WIA(1^+ or 2^+) Day 1: 100%	0%	Day 36: 50%	Day 36: 50%
30 – < 45	0%	Day 1: 100%	Day 9: 25%	Day 36: 75%	0%
≥ 45	0%	Day 1: 100%	Day 7: 75%	Day 36: 25%	0%

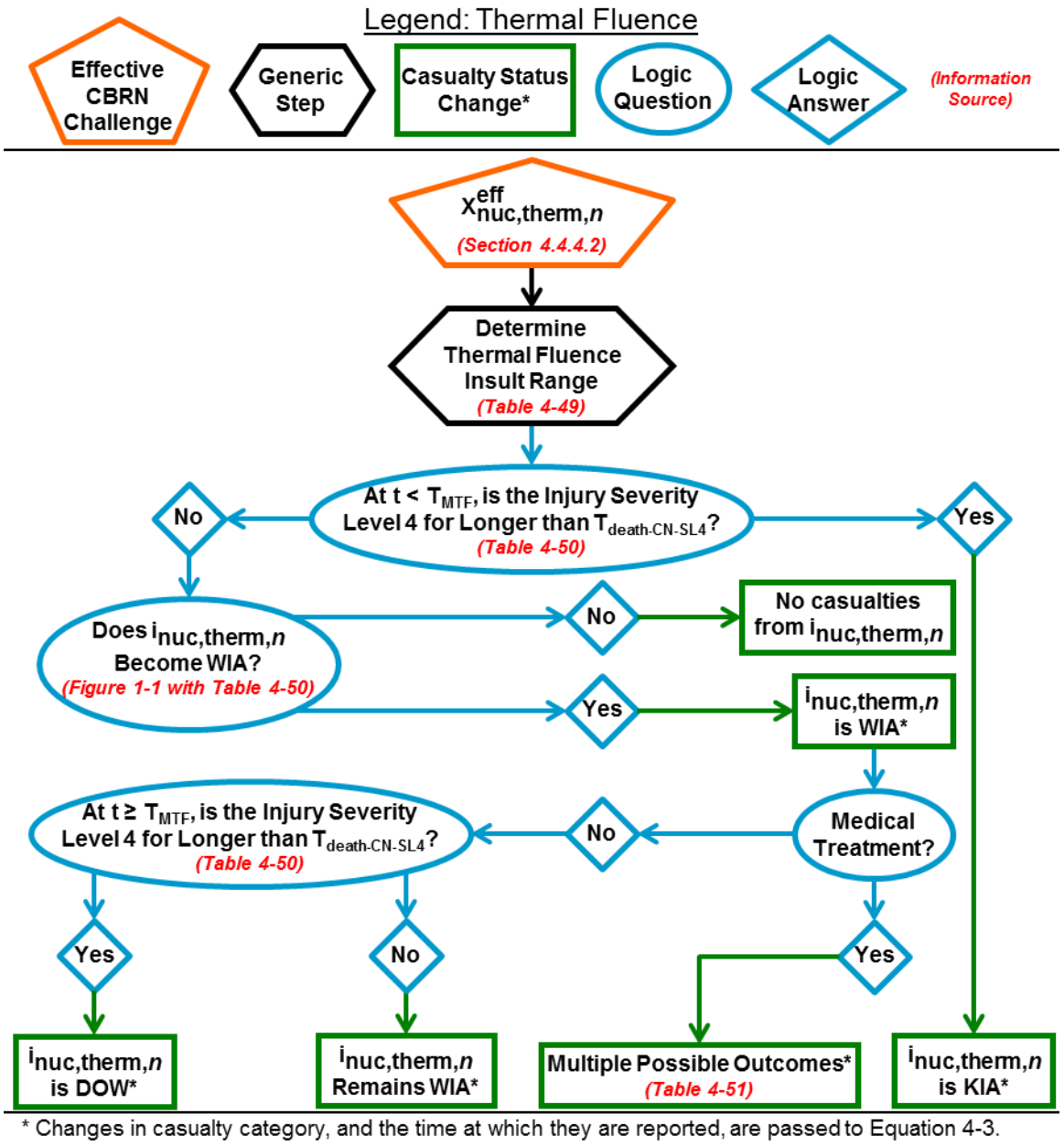


Figure 4-15: Human Response and Casualty Estimation Flowchart for Thermal Fluence From a Nuclear Detonation

4.4.5. Combined Effects of Nuclear Weapons

1. The prognosis for individuals with injuries from initial whole-body radiation injury combined with burns and/or trauma is worse than the prognosis for any of the three types of injury in isolation. The methodology incorporates this fact with the rules stated below and summarized in Figure 4-16.

2. Individuals/icons that meet the following criteria are estimated to die on Day 10, unless they die sooner for some other reason. This is reported on Day 11.

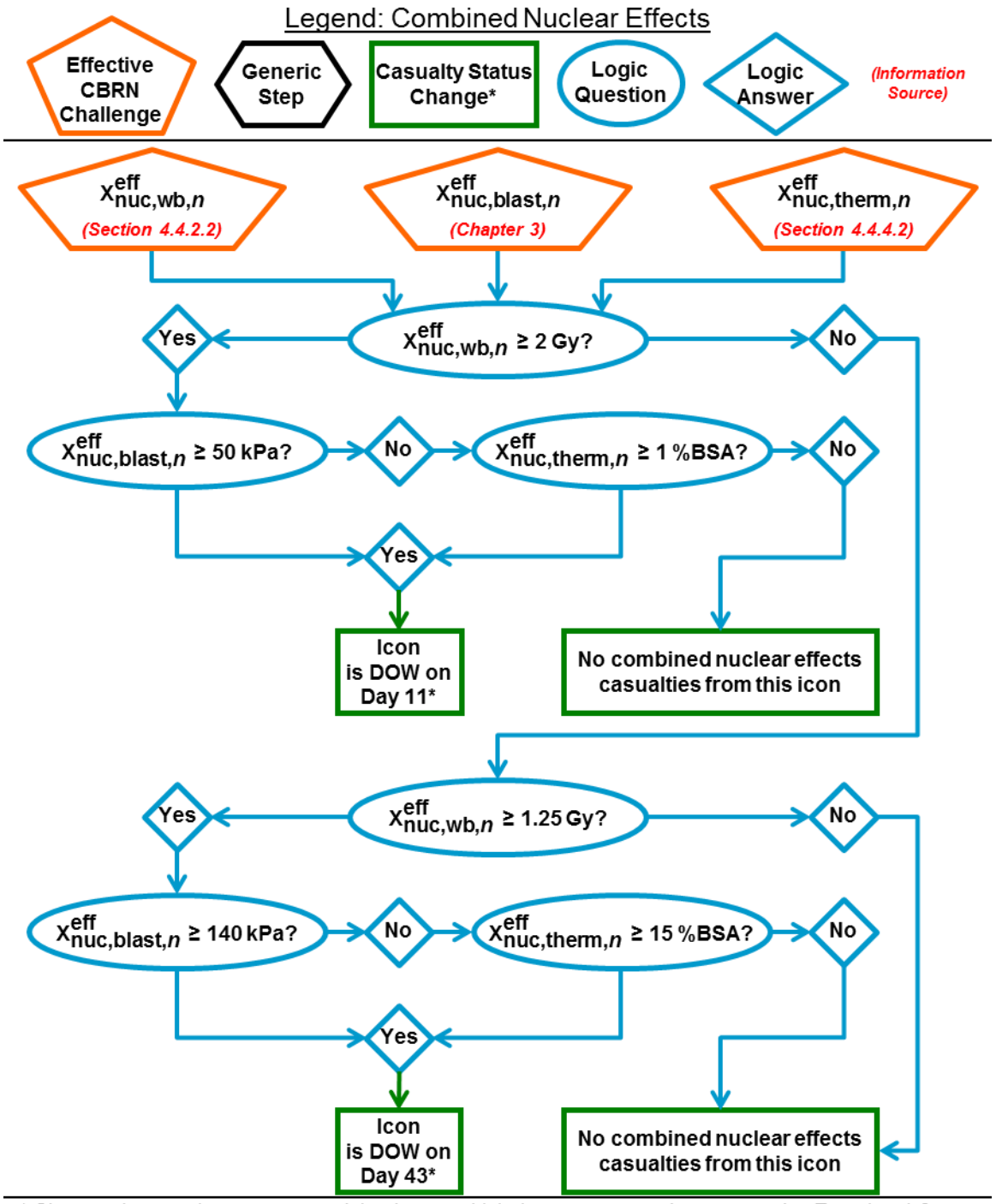
a. Total absorbed whole-body dose from initial radiation ($X^{eff}_{nuc,wb,n}$) greater than 2 Gy.

b. Primary blast insult ($X^{eff}_{nuc,blast,n}$) greater than 50 kPa and/or thermal fluence insult ($X^{eff}_{nuc,thermal,n}$) greater than 1%BSA.

3. Individuals/icons that meet the following criteria are estimated to die on Day 42, unless they die sooner for some other reason. This is reported on Day 43.

a. Total absorbed whole-body dose from initial radiation ($X^{eff}_{nuc,wb,n}$) greater than 1.25 Gy.

b. Primary blast insult ($X^{eff}_{nuc,blast,n}$) greater than 140 kPa and/or thermal fluence insult ($X^{eff}_{nuc,thermal,n}$) greater than 15%BSA.



* Changes in casualty category, and the time at which they are reported, are passed to Equation 4-3.

Figure 4-16: Casualty Estimation Flowchart for Combined Nuclear Effects

CHAPTER 5 BIOLOGICAL HUMAN RESPONSE AND CASUALTY ESTIMATION

This chapter begins with a discussion of assumptions and limitations that apply only to biological agents. Following that are full descriptions of the separate non-contagious and contagious disease human response and casualty estimation modeling frameworks. The chapter concludes with disease-specific sections describing how the methodology uses the Effective CBRN Challenge to estimate human response and casualties, including one flowchart per non-contagious disease that summarizes the process. For contagious diseases, there are separate non-contagious and contagious sections, so that a user may choose to model the disease as if it is non-contagious. In short, this chapter discusses the RESPONSE and STATUS steps of the methodology for biological agents.

5.1. BIOLOGICAL AGENT MODEL FRAMEWORK

5.1.1. Human Response Submodels

1. In contrast to CRN, human response to biological agents is modeled using population-based estimates of injury severity over time. Thus, the total number of casualties and their distribution over time are known, but the status of any particular icon or individual is not known.

2. The non-contagious human response model comprises five submodels: infectivity/effectivity,[61] incubation/latent period,[61] duration of illness, lethality, and Injury Profile. Each biological challenge type has a unique set of the five submodels.

a. Infectivity/Effectivity: estimates the fraction of each icon that will become ill (symptomatic), as a function of the icon's inhaled dose ($X^{eff}_{Q,n}$, estimated in Chapter 3). To avoid miscounting, the estimated number of ill individuals for each icon is *not* rounded to the nearest integer; a decimal number of people is reported from each icon.[62] This submodel may be characterized by an inhaled dose-dependent probability distribution or a threshold inhaled dose.

[61] For replicating organisms, infectivity and incubation period are used. For toxins, effectivity and latent period are used.

[62] Because the models are intended for application at the *population* level, the estimated decimal number of personnel from each icon must *not* be used as point estimates; the results should *only* be used at the population (aggregate) level.

b. Incubation/Latent Period: estimates the daily number of individuals who begin to manifest symptoms and enter the first stage of (symptomatic) illness. This submodel is characterized by the probability of becoming symptomatic as a function of time. It may be represented by a dose-dependent or dose-independent probability distribution or fixed value. There may be separate submodels for survivors and non-survivors.

c. Duration of Illness: estimates the daily number of individuals who move from one stage of illness to the next, die (DOW), become convalescent (CONV), and recover sufficiently to be available for return to duty (RTD), as applicable. This submodel is characterized by the probability of moving to the next stage, becoming DOW, becoming CONV, or becoming RTD, as a function of time. It may be represented by one or more dose-dependent or dose-independent probability distributions or fixed values. There may be separate submodels for survivors and non-survivors, and for treated and untreated populations.

d. Lethality: estimates the number of individuals that will die. This submodel may be characterized by an inhaled dose-dependent probability distribution that is applied individually to each challenged icon,[63] or by a CFR that is applied to the ill population (as determined by the infectivity model). Additionally, there may be separate submodels for untreated and treated populations.

e. Injury Profile: estimates the severity of the signs and symptoms associated with each stage of illness. This submodel is characterized by an assigned Injury Severity Level for each stage of illness. There may be separate submodels for survivors and non-survivors, and for treated and untreated populations.

3. The contagious human response model comprises the same five submodels plus two additional parameters related to person-to-person transmission of disease, the relative infectiousness, α, and the time-varying disease transmission rate, $\beta(d)$.

4. Consideration of medical countermeasures has different effects, depending on the challenge. Prophylaxis may reduce the probability that an individual will become ill, reduce mortality, result in milder forms of illness, or speed recovery. Treatment may reduce mortality, mitigate the severity of injury, or decrease the duration of illness.

[63] Because the models are intended for application at the *population* level, the estimated decimal number of personnel from each icon must *not* be used as point estimates; the results should *only* be used at the population (aggregate) level.

5.1.2. Casualty Estimation

For biological agents, there is no general rule to determine whether and when a casualty will die—see section 5.2 for disease-specific models.

5.1.3. Assumptions and Limitations

1. Assumptions.

   a. All challenges relate to inhalation of the aerosolized agent.

   b. The efficacy of prophylaxis and medical treatment are independent of the dose; there is no “defeat dose.”

   c. A case fatality rate (CFR) of 1% or below is negligible; a CFR of 0% will be used. Similarly, in the absence of a well-quantified CFR, 0% or 100% lethality is used in place of qualitative descriptions such as “highly lethal without treatment” or “rarely fatal.”

   d. Because of the relatively long incubation/latent periods (as compared to the time required to reach a MTF), biological agents will not cause KIA casualties.

   e. The period during which an individual is ill can be subdivided into one or more stages, and Injury Severity Levels related to signs and symptoms can be associated with these stages.

2. Limitations

   a. The methodology uses population-based estimates of injury severity over time. Thus, the casualty category of a particular icon *cannot* be tracked over time.

   b. The infectivity models were derived such that the methodology ignores “subclinical” infections; everyone who is “infected” will become symptomatic. Likewise, the effectivity models were derived such that the “effect” is the onset of signs and symptoms.

5.1.4. Non-Contagious Casualty Estimation

1. Figure 5-1 summarizes the non-contagious biological casualty estimation process. The text in this section explains the process more fully.

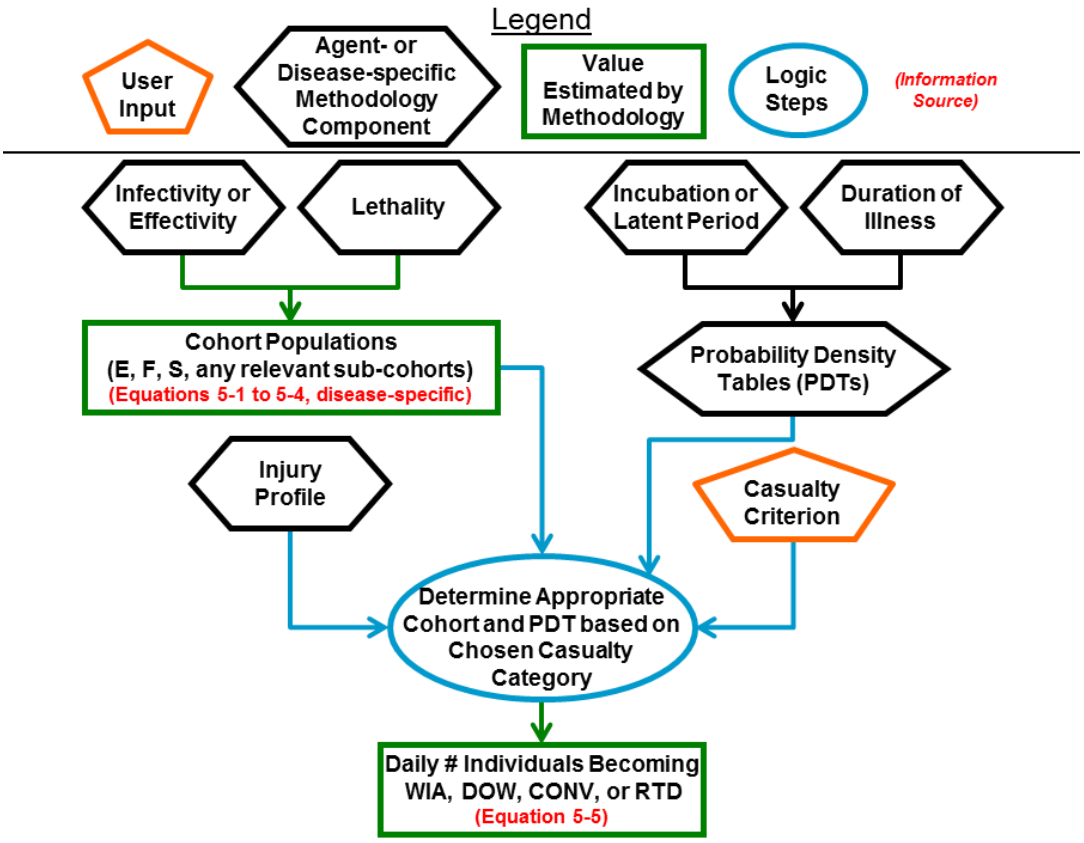


Figure 5-1: Non-Contagious Agent/Disease Casualty Estimation Flowchart

2. The first step is to use the infectivity/effectivity and lethality submodels for the challenge agent to estimate the number of individuals expected to become ill (E), the number of ill individuals expected to die (F), and the number of ill individuals expected to survive (S). These separate populations are referred to as cohorts.

a. The population of the E cohort is estimated using Equation 5-1, which sums the number of infected personnel after accounting for prophylaxis.

$$E = \sum_{n} \left(i_n \cdot (1 - \rho_n) \cdot p_E\left(X^{eff}_{Q,n}\right) \right), \qquad (5\text{-}1)$$

where:

i_n is the number of individuals in icon n,

ρ_n is the efficacy of prophylaxis against the challenge agent for all individuals at icon n [unitless, ranges from 0 to 1],

$X^{eff}_{Q,n}$ is the inhaled dose, which is estimated according to Chapter 3, and

$p_E(X^{eff}_{Q,n})$ is the probability that an individual who did not receive prophylaxis and inhaled a dose of $X^{eff}_{Q,n}$ will become ill (estimated using the infectivity/effectivity submodel for the challenge agent).

b. The population of the F cohort is estimated using one of two equations, depending on the type of lethality model associated with the challenge.

1) If the lethality model is an inhaled dose-dependent probability distribution, Equation 5-2 is used to estimate the population of the F cohort; it sums the number of personnel who received a lethal does after accounting for prophylaxis.

$$F = \sum_n \left(i_n \cdot (1 - \rho_n) \cdot p_f(X^{eff}_{Q,n}) \right), \tag{5-2}$$

where:

i_n, ρ_n, and $X^{eff}_{Q,n}$ are as defined for Equation 5-1, and

$p_f(X^{eff}_{Q,n})$ is the probability that an individual who did not receive prophylaxis and inhaled a dose of $X^{eff}_{Q,n}$ will die (estimated using the lethality model for the challenge agent[64]).

2) If the lethality model is a CFR, Equation 5-3 is used to estimate the population of the F cohort; it is a simple percentage of the ill.

$$F = E \cdot p_f(Q), \tag{5-3}$$

where $p_f(Q)$ is the probability that an ill individual will die (determined by the lethality model for the challenge agent).

c. The population of the S cohort is estimated using Equation 5-4.

$$S = E - F \tag{5-4}$$

d. For each disease, if there is some feature of the disease that dictates the cohorts listed above should be split, such as two possible presentations, or if

[64] Note that this type of lethality model is defined such that $p_E(X^{eff}_{Q,n}) \geq p_f(X^{eff}_{Q,n})$ for all $X^{eff}_{Q,n}$.

medical treatment has a relevant effect on one or more submodel, the cohorts will be split accordingly. For example, if medical treatment affects the duration of illness, the F and S cohorts might be split into F_U, F_T, S_U, and S_T, where the "U" cohorts relate to those who finish their course of disease before specific treatment is available, and the "T" cohorts relate to those who received specific treatment. As warranted, disease-specific parts of section 5.2 will provide the necessary equations and explanation.

3. The next step in the methodology is to estimate the *daily* fraction of each cohort that is in each casualty category. The methodology uses the cohort populations and disease-specific probability density tables (PDTs) derived from the incubation period and duration of illness models.

4. A single PDT correlates to a single casualty category for a single disease. For most diseases, there are multiple PDTs for individuals becoming WIA because the appropriate PDT depends upon the user-specified casualty criterion, and may also depend on other disease-specific features and the value of $Flag_{MT}$.

5. PDTs contain the results of integrating the appropriate probability density function (PDF) over the *interval* of the specified day. The user does not need to generate any PDTs unless changes are made to the underlying submodels for a specific disease.

a. For PDTs reflecting the onset of Stage 1 of illness,[65] the appropriate PDF is the PDF of the distribution used to characterize the incubation/latent period.

b. For all other PDTs for the same disease, the appropriate PDF is a convolution of multiple PDFs. For example, if non-survivors of the disease enter Stage 1, then Stage 2, and then DOW at the end of Stage 2, the PDT for the daily fraction of non-survivors (F) that DOW will contain numbers derived by convolving the PDFs associated with the incubation/latent period and the durations of Stages 1 and 2 of illness.

c. Table 5-1 is an example PDT.

[65] Such PDTs have titles in the format of "Daily Fraction of People Ill with (Disease) Who Become WIA, for Casualty Criterion WIA(X^+)."

Table 5-1: Example PDT, "Daily Fraction of Non-Survivors (F) Ill with Example Disease Who DOW"

Day (d)	Fraction, $PDT_{5\text{-}1}(d)$
1	0.5000
2	0.2276
3	0.1432
4	0.0747
5	0.0432
6	0.0113

Note: the numbers in this table are purely notional and do not reflect any real disease.

6. The set of PDTs for a given disease estimates the fraction of each cohort that becomes WIA, DOW, CONV, or RTD *during* a given day. This information must be applied carefully if the reporting rules from section 1.6.4.3 are to be followed. As applied to biological agents, those rules are:

a. Individuals who become WIA on day X must be reported as WIA on day X.

b. Individuals who move from WIA to DOW, CONV, or RTD on day X must be reported as WIA on day X and DOW, CONV, or RTD on day X+1.

c. Individuals who move from CONV to RTD on day X must be reported as CONV on day X and RTD on day X+1.

7. To determine the daily *number* of individuals that become WIA, DOW, CONV, or RTD, the *fraction* associated with the desired day within the appropriate PDT is simply multiplied by the appropriate cohort population. The approach below ensures that all casualties are reported as WIA on the day they become ill, and none are double-counted as also becoming DOW, CONV, or RTD that same day.

a. For reporting of WIA, the desired day for reporting is the day on which an individual becomes WIA. Thus, Equation 5-5 determine the reported number of WIA on a given day.

$$New_{WIA}(d) = \sum_{\text{relevant cohorts}} \left(Pop_{cohort} \cdot PDT_{5\text{-}X}(d) \right), \qquad (5\text{-}5)$$

where:

$New_{WIA}(d)$ is the number of individuals who become (and are reported as) WIA on day d, rounded to the nearest integer,

Pop_{cohort} is the population of a relevant cohort; the number of relevant cohorts and specific symbols used to refer to the cohorts are agent/disease-specific, but always follow the format E_X, F_X, or S_X, where X indicates a sub-cohort (if any),

$PDT_{5\text{-}X}(d)$ is the fraction of Pop_{cohort} that becomes (and is reported as) WIA on day d, as dictated by Table 5-X, and

the links between specific cohorts and a PDTs are specified in the agent/disease-specific flowcharts in section 5.2.

b. For reporting of DOW, CONV, and RTD, the desired day is the day after the day in which an individual becomes DOW, CONV, or RTD. Thus, Equation 5-6 is used to determine the reported number of DOW, CONV, and RTD on a given day.

$$New_{CAT}(d+1) = \sum_{\text{relevant cohorts}} \left(Pop_{cohort} \cdot PDT_{5\text{-}X}(d) \right), \tag{5-6}$$

where:

CAT is a casualty category (DOW, CONV, or RTD),

$New_{CAT}(d+1)$ is the number of individuals who are *reported* as CAT on day d+1, rounded to the nearest integer,

Pop_{cohort} is as defined for Equation 5-5,

$PDT_{5\text{-}X}(d)$ is the fraction of Pop_{cohort} that *becomes* CAT on day d, as dictated by Table 5-X, and

the links between specific cohorts and a PDTs are specified in the agent/disease-specific flowcharts in section 5.2.

8. Using the example values from Table 5-1 and assuming there are 100 people in the F cohort, the number of people who are reported DOW on day 6 is:

$$New_{DOW}(6) = F \cdot PDT_{5\text{-}1}(5) = 100 \cdot 0.0432 = 4.32 = 4$$

9. After Equation 5-6 is applied to each casualty category on each day, the methodology continues by reporting the outputs, as described in Chapter 6.

5.1.5. Contagious Casualty Estimation

Note that a new version of the SEIRP model described below is currently in development and, in SD.3, is planned to replace the version presented below. The new version will address 1) the impact of medical treatment in reducing the spread of disease, and 2) the effects of restriction of movement (isolation and quarantine). In both cases, the change will result in additional cohorts from which individuals in

other cohorts will be moved as a result of the user's chosen courses of action.

1. Depending on the casualty criterion, T_{MTF}, and the disease of interest, it may be unnecessary to use the contagious casualty estimation model. It is assumed that once an individual enters the medical system, that individual will no longer spread the disease. Thus, if the casualty criterion and Injury Profile are such that all individuals will be declared WIA upon entering Stage 1 of disease, and T_{MTF} is less than one day, the methodology will not predict an outbreak because nobody will have an opportunity to spread disease. In such cases, the user is advised to apply the non-contagious model because it is easier to use and understand. Table 5-2 summarizes the cases for which the user should and should not use the contagious models.

Table 5-2: Casualty Criterion-Dependent Recommendation for Type of Biological Model

Disease	Use Non-Contagious Models	Use Contagious Models
Plague	WIA(1^+) or WIA(2^+) AND $T_{MTF} \leq 1$ day	WIA(3^+) OR $T_{MTF} > 1$ day
Smallpox	WIA(1^+) or WIA(2^+) AND $T_{MTF} \leq 1$ day	WIA(3^+) OR $T_{MTF} > 1$ day
EVD and MVD	To be determined for SD.3	To be determined for SD.3

2. The contagious model comprises the five submodels described in section 5.1.1.2, plus two additional submodels related to person-to-person transmission. The seven submodels are used to define the values of parameters that are incorporated into the framework of an epidemic model—the Susceptible, Exposed and infected, Infectious, Removed, and Prophylaxis efficacious (SEIRP) model.

3. The SEIRP model involves sequentially solving a set of time-dependent finite-difference equations. The sequence of equations is solved once for each time step. To match the output time resolution of the overall casualty estimation methodology, the time step in the SEIRP model is 1 day.

4. The SEIRP model employs a number of cohorts, each representing a time-varying population, to describe the dynamics of an epidemic. The cohorts are defined in the following list. The sum of all other cohorts always equals N_{TOT}, the population at risk.

a. The susceptible cohort, S(d), is the fraction N_{TOT} that is not infected, but can become infected, on day d.

b. The exposed and infected cohort, E(d), is the fraction of N_{TOT} that is infected but not yet symptomatic on day *d*. E(d) is divided into two sub-cohorts (E_1(d) and E_2(d)) for the purpose of allowing a minimum incubation period in the model.

c. The infectious cohort, I(d), is the fraction of N_{TOT} that is symptomatic and

contagious on day *d*. I(d) is divided into sub-cohorts ($I_1(d)$ and $I_2(d)$) for Stage 1 and Stage 2 of disease, respectively. Each cohort is associated with a specific Injury Severity Level, based on the Injury Profile for the challenge agent.

d. The removed cohort, R(d), is the fraction of N_{TOT} that has been removed from further consideration. R(d) is divided into sub-cohorts for individuals who have died from disease and are thereby removed as a source of infection from the model ($R_f(d)$) and those who are in the medical system and are therefore assumed to not spread the disease despite their symptomatic state[66] ($R_m(d)$).

e. The prophylaxis efficacious cohort, P(d) is the fraction of N_{TOT} that has received efficacious prophylaxis, and is thereby protected against infection on day d.

5. The finite difference equations define how individuals move between cohorts. In general, individuals may move between S(d), E(d), and P(d), but once an individual reaches I(d), he may only move to R(d). The daily solutions to the finite-difference equations provide the population of each cohort at the end of each day. The populations are then used to generate the casualty estimate, as described in Chapter 6.

6. The finite-difference equations use the following parameters as inputs. The values of parameters with agent-specific values can be found in the appropriate part of section 5.2.

a. i_n is the number of individuals in icon *n*.

b. $X^{eff}_{Q,n}$ is the inhaled dose, which is estimated according to Chapter 3.

c. $p_E\left(X^{eff}_{Q,n}\right)$ is the probability that an individual who did not receive prophylaxis and inhaled a dose of $X^{eff}_{Q,n}$ will become ill (estimated using the infectivity/effectivity submodel for the challenge agent).

d. ρ_S is the efficacy of prophylaxis in S(d) [percent].

e. ρ_E is the efficacy of prophylaxis in E(d) [percent].

[66] The only effect of medical treatment that is applied to individuals in $R_m(d)$ is the decreased rate of disease spread. Other effects, such as decreased CFR or the ability to RTD, are not included. Thus, survivors enter $R_m(d)$ and remain there indefinitely.

f. μ_{E1} is the minimum time individuals spend in E(d) [days].

g. μ_{E2} is the mean time individuals spend in E(d) [days].

h. μ_1 is the mean time individuals spend in I_1(d) [days].

i. μ_2 is the mean time individuals spend in I_2(d) [days].

j. α, the relative infectiousness, is the time-invariant proportion of individuals in $I_1(d)$ who can transmit the disease to individuals in S(d) (and 1-α is the time-invariant proportion of individuals in I_2(d) who can transmit the disease to individuals in S(d)).[67]

k. β(d) is the time-varying rate of disease transmission [# new cases per infectious person per day.]

l. ν_{on}(d) is a binary parameter which dictates when prophylaxis is initiated.[68]

m. ν_{off}(d) is a binary parameter which dictates when prophylaxis is discontinued.[69]

n. p_f is the CFR.

7. Figure 5-2 shows which parameters interact with which cohorts.

[67] If α = 1, all transmission-caused new infections are due to individuals in $I_1(d)$. If α = 0, all transmission-caused new infections are due to individuals in $I_2(d)$. If α = 0.15, the number of new transmission-caused infections at any time-step is associable with 15% of the population of $I_1(d)$ and 85% of the population of $I_2(d)$.

[68] $\nu_{on}(d)$ is 1 on the day on which prophylaxis is initiated and 0 for all other days.

[69] $\nu_{off}(d)$ is 1 on the day on which prophylaxis is discontinued and 0 for all other days.

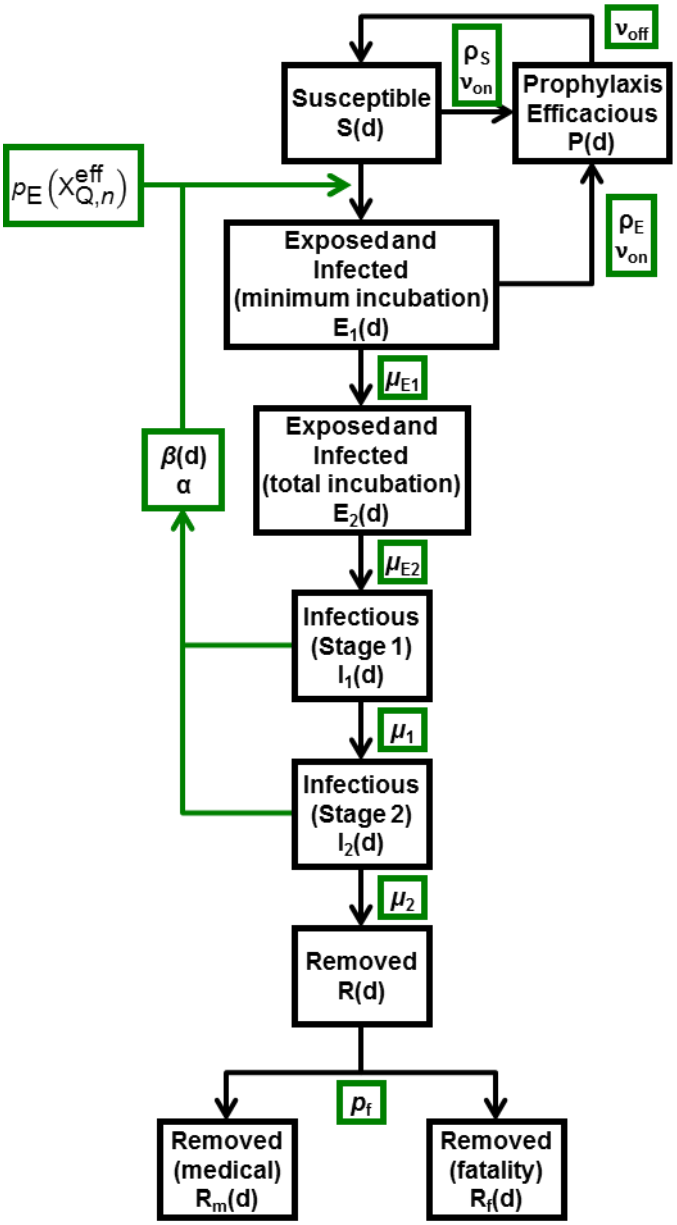


Figure 5-2: Interaction of SEIRP Cohorts and Parameters

8. The populations of the P, E,[70] and S cohorts on day zero (d = 0) are initialized by Equations 5-7 through 5-9. The I and R cohorts are assumed to have an initial population of zero.

[70] Note that $E(0) = E_1(0)$ because there is a minimum incubation period built into the model, such that $E_2(0) = 0$ in all situations.

$$P(0) = \sum_{n} \left(i_n \cdot \rho_S \right) \tag{5-7}$$

$$E(0) = E_1(0) = \sum_{n} \left(i_n \cdot \left(1 - \rho_S \right) \cdot p_E\left(X_{Q,n}^{eff} \right) \right) \tag{5-8}$$

$$S(0) = N_0 - P(0) - E(0) \tag{5-9}$$

9. Next, Equations 5-10 through 5-22 are sequentially solved for each day of interest. The final day of interest is the day at which $\beta(d)$ becomes zero and remains there, plus the average time-course of disease ($\mu_{E1} + \mu_{E2} + \mu_1 + \mu_2$).

$$P(d) = P(d-1) \cdot \left(1 - \nu_{off}(d-1) \right) + \nu_{on}(d-1) \cdot \left(\rho_S \cdot S(d-1) + \rho_E \cdot E(d-1) \right) \tag{5-10}$$

$$S(d) = S(d-1) \cdot \left(1 - \frac{\beta(d-1) \cdot \left(\alpha \cdot I_1(d-1) + (1-\alpha) \cdot I_2(d-1) \right)}{N_0} - \rho_S \cdot \nu_{on}(d-1) \right) + \nu_{off}(d-1) \cdot P(d-1) \tag{5-11}$$

If $d < \mu_{E1}$,

$$E_1(d) = E_1(d-1) \cdot \left(1 - \rho_E \cdot \nu_{on}(d-1) \right) \tag{5-12}$$

$$E_2(d) = 0 \tag{5-13}$$

If $d = \mu_{E1}$,

$$E_1(d) = 0 \tag{5-14}$$

$$E_2(d) = E_1(d-1) \tag{5-15}$$

If $d > \mu_{E1}$,

$$E_1(d) = E_1(d-1) \cdot \left(1 - \rho_E \cdot \nu_{on}(d-1) - \frac{1}{\mu_{E1}} \right) + \frac{S(d-1) \cdot \beta(d-1) \cdot \left(\alpha \cdot I_1(d-1) + (1-\alpha) \cdot I_2(d-1) \right)}{N_0} \tag{5-16}$$

$$E_2(d) = E_2(d-1) \cdot \left(1 - \frac{1}{\mu_{E2}} \right) + \frac{E_1(d-1)}{\mu_{E1}} \tag{5-17}$$

$$I_1(d) = I_1(d\text{-}1) \cdot \left(1-\frac{1}{\mu_1}\right) + \frac{E_2(d\text{-}1)}{\mu_{E2}} \quad (5\text{-}18)$$

$$I_2(d) = I_2(d\text{-}1) \cdot \left(1-\frac{1}{\mu_2}\right) + \frac{I_1(d\text{-}1)}{\mu_1} \quad (5\text{-}19)$$

$$R(d) = R(d\text{-}1) + \frac{I_2(d\text{-}1)}{\mu_2} \quad (5\text{-}20)$$

$$R_f(d) = R(d) \cdot p_f \quad (5\text{-}21)$$

$$R_m(d) = R(d) - R_f(d) \quad (5\text{-}22)$$

10. Finally, Equations 5-23 through 5-28 are used to generate the required outputs for casualty reporting (reporting is described in Chapter 6).

$$I_{1,new}(d) = \frac{E_2(d\text{-}1)}{\mu_{E2}} \quad (5\text{-}23)$$

$$I_{2,new}(d) = \frac{I_1(d\text{-}1)}{\mu_1} \quad (5\text{-}24)$$

$$R_{f,new}(d) = p_f \cdot \frac{I_2(d\text{-}1)}{\mu_2} \quad (5\text{-}25)$$

$$R_{m,new}(d) = \left(1-p_f\right) \cdot \frac{I_2(d\text{-}1)}{\mu_2} \quad (5\text{-}26)$$

$$New_{WIA}(d) = Pop_{\text{relevant "new" cohort}}(d) \quad (5\text{-}27)$$

$$New_{CAT}(d+1) = Pop_{\text{relevant "new" cohort}}(d), \quad (5\text{-}28)$$

where:

CAT is a casualty category (DOW, CONV, or RTD),

$New_{WIA}(d)$ is the number of individuals who become (and are reported as) WIA on day d, rounded to the nearest integer,

$New_{CAT}(d+1)$ is the number of individuals who are reported as CAT on day d+1 and remain there until at least the next day, rounded to the nearest integer, and

$Pop_{relevant\ "new"\ cohort}(d)$ is the population of the relevant "new" cohort on day d; the potentially relevant cohorts for each casualty category are defined in Table 5-3, and their daily populations are defined in Equations 5-23 through 5-26.

Table 5-3: Cohorts Relevant to Contagious Biological Casualty Estimation

CAT	Possibly Relevant Cohorts	Caveats to Relevance of Cohort(s)
WIA	$I_{1,new}(d)$ or $I_{2,new}(d)$	Depends on the casualty criterion (see Figure 1-1) and disease-specific Injury Profile
DOW	$R_{f,new}(d)$	
CONV	$R_{m,new}(d)$	Depends on the agent-specific treatment model
RTD	$R_{m,new}(d)$	Depends on the agent-specific treatment model

10. Assumptions, limitations, and constraints.

    a. Assumptions.

        1) The population is large and unstructured.

        2) The population mixes homogeneously.

        3) Initial and transmission-caused infections follow the same course of disease.

        4) The epidemiological circumstances of the historical outbreaks from which the time-varying rate of disease transmission was derived are similar to the circumstances in scenarios of interest to the user.

    b. Limitation. The model does not account for medical treatment in any way. If the user sets $Flag_{MT}$ to Yes, the only difference in output is that survivors become RTD instead of remaining as WIA.

    c. Constraints.

        1) Because the SEIRP model uses only mean times (and not standard deviations) to represent the lengths of the incubation period and each stage of illness, it represents all probability distributions as exponential distributions.

        2) The SEIRP model uses finite-difference equations instead of differential equations and integrals (this introduces some unknown degree of inaccuracy).

5.2. BIOLOGICAL AGENT MODELS

5.2.1. Anthrax

1. Figure 5-3 summarizes the human response and casualty estimation processes for anthrax, Table 5-6 summarizes the Injury Profile, Table 5-8 summarizes the other anthrax submodels, and Table 5-7 summarizes the available anthrax prophylaxis options.

2. Cohorts and special considerations.

   a. The incubation period of anthrax is dose-dependent. Thus, the cohorts are stratified according to dose range, and the PDTs contain unique probability distributions for each dose range. Table 5-4 summarizes the dose ranges. The E, F, and S cohorts are split into sub-cohorts labeled as E_{DR}, F_{DR}, and S_{DR}, where DR is the dose range label given in Table 5-4. The population of each E, F, and S sub-cohort is calculated separately for each dose range by applying Equations 5-1, 5-3, and 5-4 to the appropriate range of doses.

Table 5-4: Anthrax Dose Ranges

Dose Range Label	Dose Range (spores)
A	$\leq 10^2$
B	$10^2 < - \leq 10^3$
C	$10^3 < - \leq 10^4$
D	$10^4 < - \leq 10^5$
E	$10^5 < - \leq 10^6$
F	$10^6 < - \leq 10^7$
G	$>10^7$

   b. If $Flag_{MT}$ = No, the populations of the E_{DR} cohorts move to the $F_{DR,U}$ cohorts as individuals DOW. There are no $S_{DR,U}$ cohorts because the untreated lethality model is a 100% CFR (see Table 5-8).

   c. If $Flag_{MT}$ = Yes, different lethality and duration of illness models are used depending on whether individuals are in Stage 1 or Stage 2 of illness when they begin receiving treatment (see Table 5-8). The user must specify the day on which treatment becomes available for those declared WIA ($d_{trt\text{-}anth}$). Based on $d_{trt\text{-}anth}$ and the casualty criterion, the populations of the E_{DR} sub-cohorts are split among several sub-cohorts, as specified below. Note that the model does *not* apply antibiotics to every person on $d_{trt\text{-}anth}$; those who are declared WIA after $d_{trt\text{-}anth}$ are modeled to begin receiving antibiotics on the day they are declared WIA.

      1) If the casualty criterion is WIA(1^+) or WIA(2^+), the E_{DR} sub-cohorts are split among the following list of sub-cohorts, according to Equations 5-29

to 5-33.

a) $F_{DR,U}$ is the number of individuals in dose range DR who die before $d_{trt\text{-}anth}$.

b) $F_{DR,T\text{-}2}$ is the number of individuals in dose range DR who are in Stage 2 on $d_{trt\text{-}anth}$, and will die despite treatment.

c) $F_{DR,T\text{-}1}$ is the number of individuals in dose range DR who are in Stage 1 on $d_{trt\text{-}anth}$, and will die despite treatment.

d) $S_{DR,T\text{-}1}$ is the number of individuals in dose range DR who are in Stage 1 on $d_{trt\text{-}anth}$, and will survive as a result of treatment.

$$F_{DR,U} = E_{DR} \cdot \sum_{d=1}^{d_{trt\text{-}anth}} PDT_{5\text{-}9}(d) \tag{5-29}$$

$$F_{DR,T\text{-}2} = \left(E_{DR} \cdot \sum_{d=1}^{d_{trt\text{-}anth}} PDT_{5\text{-}8}(d) \right) - F_{DR,U} \tag{5-30}$$

$$F_{DR,T\text{-}1} = E_{DR} \cdot \left[\sum_{d_{Stg1}=1}^{d_{trt\text{-}anth}} \left(p_{f,T\text{-}1} \cdot PDT_{5\text{-}7}(d_{Stg1}) \cdot P_{in\text{-}Stg1} \right) + 0.1 \cdot \left(1 - \sum_{d=1}^{d_{trt\text{-}anth}} PDT_{5\text{-}7}(d) \right) \right] \tag{5-31}$$

$$S_{DR,T\text{-}1} = E_{DR} - F_{DR,U} - F_{DR,T\text{-}2} - F_{DR,T\text{-}1} \tag{5-32}$$

$$p_{f,T\text{-}1} = 0.012 \cdot (d_{trt\text{-}anth} - d_{Stg1}) + 0.1 \tag{5-33}$$

In Equations 5-29 to 5-33:

$d_{trt\text{-}anth}$ is the user-specified day on which treatment begins,

d_{Stg1} is the day on which different fractions of E_{DR} enter Stage 1,

$(d_{trt\text{-}anth} - d_{Stg1})$ is the number of days between the onset of symptoms and the beginning of antibiotic treatment.

$PDT_{5\text{-}X}(d \text{ or } d_{Stg1})$ reflect fractions of a specific population that have entered a certain stage of disease, as a function of a chosen day

(d or d_{Stg1}), as dictated by Table 5-X,

$p_{f,T-1}$ is the probability of fatality for anthrax patients whose treatment is initiated in Stage 1,

$P_{in\text{-}Stg1}$ is the probability that an individual who entered Stage 1 of anthrax ($d_{trt\text{-}anth} - d_{Stg1}$) days ago is still in Stage 1 (see Table 5-5).

2) If the casualty criterion is WIA(3^+), the E_{DR} sub-cohorts are split among the $F_{DR,U}$ and $F_{DR,T-2}$ sub-cohorts, according to Equations 5-34 and 5-35

$$F_{DR,U} = E_{DR} \cdot \sum_{d=1}^{d_{trt\text{-}anth}} PDT_{5\text{-}9}(d) \qquad (5\text{-}34)$$

$$F_{DR,T-2} = E_{DR} - F_{DR,U} \qquad (5\text{-}35)$$

Table 5-5: Probability of an Individual Still Being in Stage 1 of Anthrax ($P_{In\text{-}Stg1}$) After Specified Durations Spent in Stage 1

Days After Entering Stage 1 ($d_{trt\text{-}anth} - d_{Stg1}$)	Probability ($P_{in\text{-}Stg1}$)	Days After Entering Stage 1 ($d_{trt\text{-}anth} - d_{Stg1}$)	Probability ($P_{in\text{-}Stg1}$)	Days After Entering Stage 1 ($d_{trt\text{-}anth} - d_{Stg1}$)	Probability ($P_{in\text{-}Stg1}$)
0	1.0000	9	0.0407	18	0.0010
1	0.9946	10	0.0257	19	0.0007
2	0.8835	11	0.0164	20	0.0005
3	0.6558	12	0.0106	21	0.0004
4	0.4362	13	0.0069	22	0.0003
5	0.2755	14	0.0046	23	0.0002
6	0.1705	15	0.0031	24	0.0001
7	0.1051	16	0.0021	25	0.0000
8	0.0651	17	0.0014		

3. Assumptions.

a. The disease resulting from exposure to *B. anthracis* is inhalation anthrax.

b. Untreated inhalation anthrax is 100% lethal.

4. Table 5-9 through Table 5-15 are the PDTs for anthrax. The dose-bin specific values in a given table are to be used in Equation 5-5 or 5-6 with the sub-cohorts listed in the table header.

Table 5-6: Anthrax Injury Profile

Stage	Injury Severity Level
Untreated Non-Survivors ($F_{DR,U}$)	
1	2
2	4
Stage 1 Treated Survivors ($S_{DR,T-1}$)	
1	2
2	4
3	3
4	2
Stage 1 ($F_{DR,T-1}$) and Stage 2 ($F_{DR,T-2}$) Treated Non-Survivors	
1	2
2	4

Table 5-7: Anthrax Prophylaxis Summary

Type of Prophylaxis	Efficacy (ρ_n)
Pre-exposure vaccination	0.90
Post-exposure antibiotics	0.90
Pre-exposure vaccination and post-exposure antibiotics	1.00
Post-exposure vaccination and antibiotics	1.00

Table 5-8: Anthrax Submodel Summary

Type	Parameter Values (basis of derived values)
Infectivity ($p_F(X^{eff}_{anthrax,n})$)	
Lognormal Distribution	$\mu = 9.741$; $\sigma = 2.915$ (ID_{50} = 17,000 spores; probit slope = 0.79 probits/log(dose))
Lethality (p_f(anthrax))	
Untreated OR Treatment Initiated in Stage 2	
CFR	100%
Treatment Initiated in Stage 1	
Linear Function	$m = 0.012$ $(days)^{-1}$; $b = 0.1$
Incubation Period*	
Parametric Lognormal Distribution	$\alpha = 10.3$; $\beta = -1.35$; $\gamma = 0.804$; $\delta = -0.079$ (mean and standard deviation are dose-dependent)
Duration of Illness*	
Stage 1: Untreated ($F_{DR,U}$) Stage 1: Treatment Initiated in Stage 2 ($F_{DR,T-2}$)	
Lognormal Distribution	$\mu = 1.304$; $\sigma = 0.5121$ (mean = 4.2 days; standard deviation = 2.3 days)
Stage 2: Untreated ($F_{DR,U}$)	
Lognormal Distribution	$\mu = -0.7318$; $\sigma = 0.8662$ (mean = 0.70 days; standard deviation = 0.74 days)
Stage 1: Treatment Initiated in Stage 1 ($S_{DR,T-1}$ and $F_{DR,T-1}$)	
Lognormal Distribution	$\mu = 1.702$; $\sigma = 0.3352$ (mean = 5.8 days; standard deviation = 2.0 days)
Stage 2: Treatment Initiated in Stage 1 ($S_{DR,T-1}$ and $F_{DR,T-1}$)	
Lognormal Distribution	$\mu = -0.1514$; $\sigma = 0.9878$ (mean = 1.4 days; standard deviation = 1.8 days)
Stage 3: Treatment Initiated in Stage 1 ($S_{DR,T-1}$)	
Constant	11 days
Stage 4: Treatment Initiated in Stage 1 ($S_{DR,T-1}$)	
Constant	60 days
Stage 2: Treatment Initiated in Stage 2 ($F_{DR,T-2}$)	
Lognormal Distribution	$\mu = 0.1253$; $\sigma = 0.7485$ (mean = 1.5 days; standard deviation = 1.3 days)

* Presented for information only. These two submodels have already been convolved to generate the PDTs; the user should use the PDTs to estimate when changes in casualty category occur.

**Table 5-9: Daily Fraction of Ill Individuals (E_{DR}) Who Become WIA with Anthrax, for Casualty Criterion WIA(1^+) or WIA(2^+)*

Day	Dose Range†						
	$\leq 10^2$ spores	$10^2 < - \leq 10^3$ spores	$10^3 < - \leq 10^4$ spores	$10^4 < - \leq 10^5$ spores	$10^5 < - \leq 10^6$ spores	$10^6 < - \leq 10^7$ spores	$>10^7$ spores
1	0.0008	0.0006	0.0006	0.0010	0.0084	0.7413	0.9998
2	0.0185	0.0216	0.0326	0.0793	0.3779	0.2583	0.0002
3	0.0557	0.0755	0.1242	0.2600	0.4400	0.0004	0.0000
4	0.0851	0.1179	0.1814	0.2745	0.1386	0.0000	0.0000
5	0.0982	0.1313	0.1778	0.1840	0.0286	0.0000	0.0000
6	0.0988	0.1243	0.1444	0.1015	0.0052	0.0000	0.0000
7	0.0921	0.1079	0.1066	0.0513	0.0010	0.0000	0.0000
8	0.0823	0.0891	0.0749	0.0250	0.0003	0.0000	0.0000
9	0.0716	0.0716	0.0512	0.0120	0.0000	0.0000	0.0000
10	0.0613	0.0565	0.0345	0.0058	0.0000	0.0000	0.0000
11	0.0519	0.0442	0.0231	0.0028	0.0000	0.0000	0.0000
12	0.0438	0.0344	0.0155	0.0014	0.0000	0.0000	0.0000
13	0.0368	0.0267	0.0104	0.0007	0.0000	0.0000	0.0000
14	0.0308	0.0208	0.0071	0.0004	0.0000	0.0000	0.0000
15	0.0259	0.0162	0.0048	0.0002	0.0000	0.0000	0.0000
16	0.0217	0.0126	0.0033	0.0001	0.0000	0.0000	0.0000
17	0.0182	0.0099	0.0023	0.0000	0.0000	0.0000	0.0000
18	0.0154	0.0078	0.0016	0.0000	0.0000	0.0000	0.0000
19	0.0129	0.0061	0.0011	0.0000	0.0000	0.0000	0.0000
20	0.0109	0.0048	0.0008	0.0000	0.0000	0.0000	0.0000
21	0.0093	0.0038	0.0005	0.0000	0.0000	0.0000	0.0000
22	0.0079	0.0031	0.0004	0.0000	0.0000	0.0000	0.0000
23	0.0067	0.0024	0.0003	0.0000	0.0000	0.0000	0.0000
24	0.0057	0.0020	0.0002	0.0000	0.0000	0.0000	0.0000
25	0.0049	0.0016	0.0001	0.0000	0.0000	0.0000	0.0000
26	0.0042	0.0013	0.0001	0.0000	0.0000	0.0000	0.0000
27	0.0036	0.0010	0.0001	0.0000	0.0000	0.0000	0.0000
28	0.0031	0.0008	0.0001	0.0000	0.0000	0.0000	0.0000
29	0.0027	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000
30	0.0023	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000
31	0.0020	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000
32	0.0017	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000
33	0.0015	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000
34	0.0013	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000
35	0.0012	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
36	0.0010	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
37	0.0009	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
38	0.0008	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
39	0.0007	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
40	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
41	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
42	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
43	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
44	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
45	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000

Day	Dose Range†						
	$\leq 10^2$ spores	$10^2 < - \leq 10^3$ spores	$10^3 < - \leq 10^4$ spores	$10^4 < - \leq 10^5$ spores	$10^5 < - \leq 10^6$ spores	$10^6 < - \leq 10^7$ spores	$>10^7$ spores
46	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
47	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
48	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
49	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
50	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
51	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
52	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
53	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
54	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
55	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
56	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
57	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
58	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
59	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
60	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
61	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
62	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
63	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
64	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
65	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
66	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
67	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
68	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
≥69	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

* Since this table indicates the days on which fractions of cohorts enter Stage 1 of illness, it is also used in Equation 5-31 to estimate the populations of the $F_{DR,T-1}$ cohorts.

† Table values were calculated using the upper dose specified in each column heading, with the exception of the last column, which used $2 \cdot 10^7$ spores; each column is to be used for the range of inhaled doses specified in the column heading.

Table 5-10: Daily Fraction of Ill Individuals (E_{DR}) Who Become WIA with Anthrax, for Casualty Criterion WIA(3+)*

Day	Dose Range†						
	$\leq 10^2$ spores	$10^2 < - \leq 10^3$ spores	$10^3 < - \leq 10^4$ spores	$10^4 < - \leq 10^5$ spores	$10^5 < - \leq 10^6$ spores	$10^6 < - \leq 10^7$ spores	$>10^7$ spores
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002
2	0.0000	0.0000	0.0000	0.0000	0.0002	0.0132	0.0451
3	0.0007	0.0007	0.0010	0.0023	0.0134	0.1296	0.1889
4	0.0055	0.0066	0.0102	0.0236	0.0872	0.2290	0.2346
5	0.0179	0.0234	0.0373	0.0774	0.1803	0.2127	0.1893
6	0.0363	0.0489	0.0762	0.1358	0.2068	0.1537	0.1289
7	0.0554	0.0746	0.1101	0.1645	0.1738	0.0999	0.0817
8	0.0705	0.0929	0.1273	0.1585	0.1238	0.0621	0.0503
9	0.0794	0.1012	0.1272	0.1317	0.0810	0.0380	0.0307
10	0.0823	0.1005	0.1148	0.0994	0.0508	0.0232	0.0188
11	0.0805	0.0934	0.0966	0.0703	0.0313	0.0142	0.0115
12	0.0754	0.0829	0.0773	0.0477	0.0192	0.0088	0.0072
13	0.0686	0.0711	0.0596	0.0315	0.0118	0.0055	0.0045
14	0.0610	0.0594	0.0448	0.0204	0.0073	0.0035	0.0029
15	0.0534	0.0488	0.0330	0.0131	0.0046	0.0022	0.0018
16	0.0462	0.0396	0.0240	0.0084	0.0029	0.0014	0.0012
17	0.0396	0.0318	0.0173	0.0054	0.0019	0.0009	0.0008
18	0.0338	0.0254	0.0124	0.0034	0.0012	0.0006	0.0005
19	0.0287	0.0202	0.0088	0.0022	0.0008	0.0004	0.0004
20	0.0243	0.0160	0.0063	0.0014	0.0005	0.0003	0.0002
21	0.0206	0.0127	0.0045	0.0009	0.0004	0.0002	0.0002
22	0.0174	0.0100	0.0032	0.0006	0.0002	0.0001	0.0001
23	0.0147	0.0079	0.0023	0.0004	0.0002	0.0001	0.0001
24	0.0125	0.0063	0.0016	0.0003	0.0001	0.0001	0.0001
25	0.0106	0.0050	0.0012	0.0002	0.0001	0.0001	0.0000
26	0.0090	0.0040	0.0008	0.0001	0.0001	0.0001	0.0000
27	0.0076	0.0032	0.0006	0.0001	0.0001	0.0001	0.0000
28	0.0065	0.0025	0.0004	0.0001	0.0000	0.0000	0.0000
29	0.0055	0.0020	0.0003	0.0001	0.0000	0.0000	0.0000
30	0.0047	0.0016	0.0002	0.0001	0.0000	0.0000	0.0000
31	0.0041	0.0013	0.0002	0.0001	0.0000	0.0000	0.0000
32	0.0035	0.0011	0.0001	0.0000	0.0000	0.0000	0.0000
33	0.0030	0.0009	0.0001	0.0000	0.0000	0.0000	0.0000
34	0.0026	0.0007	0.0001	0.0000	0.0000	0.0000	0.0000
35	0.0022	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000
36	0.0019	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000
37	0.0017	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000
38	0.0015	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000
39	0.0013	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000
40	0.0011	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
41	0.0010	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
42	0.0009	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
43	0.0008	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
44	0.0007	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
45	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000

Day	Dose Range†						
	$\leq 10^2$ spores	$10^2 < - \leq 10^3$ spores	$10^3 < - \leq 10^4$ spores	$10^4 < - \leq 10^5$ spores	$10^5 < - \leq 10^6$ spores	$10^6 < - \leq 10^7$ spores	$>10^7$ spores
46	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
47	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
48	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
49	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
50	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
51	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
52	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
53	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
54	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
55	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
56	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
57	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
58	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
59	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
60	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
61	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
62	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
63	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
64	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
65	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
66	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
≥67	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

* Since this table indicates the days on which fractions of cohorts enter Stage 2 of illness, it is also used in Equation 5-30 to estimate the populations of the $F_{DR,T-2}$ cohorts.

† Table values were calculated using the upper dose specified in each column heading, with the exception of the last column, which used $2 \cdot 10^7$ spores; each column is to be used for the range of inhaled doses specified in the column heading.

Table 5-11: Daily Fraction of Untreated Anthrax Non-Survivors ($F_{DR,U}$) Who DOW

Day	Dose Range*						
	$\leq 10^2$ spores	$10^2 < - \leq 10^3$ spores	$10^3 < - \leq 10^4$ spores	$10^4 < - \leq 10^5$ spores	$10^5 < - \leq 10^6$ spores	$10^6 < - \leq 10^7$ spores	$>10^7$ spores
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0022	0.0111
3	0.0002	0.0002	0.0002	0.0005	0.0034	0.0560	0.1048
4	0.0023	0.0026	0.0039	0.0092	0.0399	0.1701	0.2030
5	0.0099	0.0126	0.0199	0.0434	0.1233	0.2148	0.2091
6	0.0244	0.0325	0.0513	0.0985	0.1863	0.1851	0.1638
7	0.0427	0.0575	0.0874	0.1438	0.1890	0.1335	0.1127
8	0.0599	0.0799	0.1143	0.1589	0.1530	0.0884	0.0729
9	0.0726	0.0944	0.1252	0.1465	0.1089	0.0561	0.0458
10	0.0795	0.0997	0.1213	0.1195	0.0722	0.0350	0.0285
11	0.0809	0.0971	0.1077	0.0898	0.0461	0.0217	0.0177
12	0.0783	0.0893	0.0899	0.0637	0.0289	0.0135	0.0110
13	0.0729	0.0788	0.0717	0.0435	0.0180	0.0084	0.0069
14	0.0660	0.0673	0.0553	0.0289	0.0112	0.0053	0.0044
15	0.0586	0.0562	0.0416	0.0189	0.0070	0.0034	0.0028
16	0.0512	0.0462	0.0307	0.0123	0.0045	0.0022	0.0018
17	0.0442	0.0374	0.0224	0.0079	0.0028	0.0014	0.0012
18	0.0379	0.0301	0.0162	0.0051	0.0018	0.0009	0.0008
19	0.0324	0.0240	0.0116	0.0033	0.0012	0.0006	0.0005
20	0.0275	0.0191	0.0083	0.0021	0.0008	0.0004	0.0004
21	0.0233	0.0152	0.0059	0.0014	0.0005	0.0003	0.0002
22	0.0197	0.0120	0.0042	0.0009	0.0004	0.0002	0.0002
23	0.0167	0.0095	0.0030	0.0006	0.0002	0.0001	0.0001
24	0.0141	0.0076	0.0022	0.0004	0.0002	0.0001	0.0001
25	0.0120	0.0060	0.0015	0.0003	0.0001	0.0001	0.0001
26	0.0102	0.0048	0.0011	0.0002	0.0001	0.0001	0.0001
27	0.0086	0.0038	0.0008	0.0001	0.0001	0.0001	0.0000
28	0.0073	0.0030	0.0006	0.0001	0.0001	0.0000	0.0000
29	0.0063	0.0024	0.0004	0.0001	0.0000	0.0000	0.0000
30	0.0053	0.0019	0.0003	0.0001	0.0000	0.0000	0.0000
31	0.0046	0.0016	0.0002	0.0000	0.0000	0.0000	0.0000
32	0.0039	0.0013	0.0002	0.0000	0.0000	0.0000	0.0000
33	0.0034	0.0010	0.0001	0.0000	0.0000	0.0000	0.0000
34	0.0029	0.0008	0.0001	0.0000	0.0000	0.0000	0.0000
35	0.0025	0.0007	0.0001	0.0000	0.0000	0.0000	0.0000
36	0.0022	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000
37	0.0019	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000
38	0.0016	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000
39	0.0014	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000
40	0.0012	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000
41	0.0011	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
42	0.0009	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
43	0.0008	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
44	0.0007	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
45	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000

Day	Dose Range*						
	$\leq 10^2$ spores	$10^2 < - \leq 10^3$ spores	$10^3 < - \leq 10^4$ spores	$10^4 < - \leq 10^5$ spores	$10^5 < - \leq 10^6$ spores	$10^6 < - \leq 10^7$ spores	$>10^7$ spores
46	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
47	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
48	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
49	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
50	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
51	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
52	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
53	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
54	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
55	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
56	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
57	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
58	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
59	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
60	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
61	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
62	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
63	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
64	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
65	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
66	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
67	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
68	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
69	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
70	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
71	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
72	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
73	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
≥74	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

* Table values were calculated using the upper dose specified in each column heading, with the exception of the last column, which used $2 \cdot 10^7$ spores; each column is to be used for the range of inhaled doses specified in the column heading.

Table 5-12: Daily Fraction of Stage 1 Treated Anthrax Non-Survivors ($F_{DR,T-1}$) Who DOW

Day	Dose Range*						
	$\leq 10^2$ spores	$10^2 < - \leq 10^3$ spores	$10^3 < - \leq 10^4$ spores	$10^4 < - \leq 10^5$ spores	$10^5 < - \leq 10^6$ spores	$10^6 < - \leq 10^7$ spores	$>10^7$ spores
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0014
4	0.0000	0.0000	0.0000	0.0001	0.0005	0.0099	0.0234
5	0.0005	0.0005	0.0007	0.0017	0.0082	0.0584	0.0903
6	0.0028	0.0034	0.0053	0.0120	0.0420	0.1348	0.1618
7	0.0096	0.0124	0.0196	0.0407	0.1031	0.1821	0.1873
8	0.0219	0.0291	0.0454	0.0845	0.1567	0.1790	0.1672
9	0.0380	0.0509	0.0766	0.1251	0.1737	0.1448	0.1273
10	0.0543	0.0721	0.1030	0.1460	0.1557	0.1038	0.0878
11	0.0675	0.0878	0.1175	0.1435	0.1209	0.0690	0.0570
12	0.0758	0.0956	0.1186	0.1243	0.0852	0.0438	0.0357
13	0.0791	0.0958	0.1094	0.0982	0.0564	0.0272	0.0221
14	0.0780	0.0903	0.0941	0.0724	0.0359	0.0167	0.0136
15	0.0737	0.0811	0.0769	0.0508	0.0224	0.0103	0.0084
16	0.0676	0.0704	0.0604	0.0344	0.0138	0.0065	0.0053
17	0.0605	0.0594	0.0461	0.0227	0.0086	0.0041	0.0034
18	0.0532	0.0492	0.0344	0.0148	0.0054	0.0027	0.0022
19	0.0462	0.0402	0.0253	0.0096	0.0035	0.0018	0.0015
20	0.0398	0.0324	0.0184	0.0062	0.0023	0.0012	0.0010
21	0.0340	0.0260	0.0133	0.0040	0.0015	0.0009	0.0007
22	0.0290	0.0207	0.0095	0.0026	0.0010	0.0006	0.0005
23	0.0246	0.0165	0.0068	0.0018	0.0007	0.0004	0.0004
24	0.0209	0.0131	0.0049	0.0012	0.0005	0.0003	0.0003
25	0.0177	0.0104	0.0035	0.0008	0.0004	0.0003	0.0002
26	0.0150	0.0083	0.0026	0.0006	0.0003	0.0002	0.0002
27	0.0127	0.0066	0.0019	0.0004	0.0002	0.0002	0.0002
28	0.0108	0.0053	0.0014	0.0003	0.0002	0.0001	0.0002
29	0.0092	0.0042	0.0010	0.0002	0.0001	0.0001	0.0001
30	0.0078	0.0034	0.0007	0.0002	0.0001	0.0001	0.0001
31	0.0067	0.0027	0.0006	0.0001	0.0001	0.0001	0.0001
32	0.0057	0.0022	0.0004	0.0001	0.0001	0.0001	0.0001
33	0.0049	0.0018	0.0003	0.0001	0.0001	0.0001	0.0001
34	0.0042	0.0014	0.0002	0.0001	0.0001	0.0001	0.0001
35	0.0036	0.0012	0.0002	0.0001	0.0001	0.0000	0.0000
36	0.0031	0.0010	0.0001	0.0001	0.0001	0.0000	0.0000
37	0.0027	0.0008	0.0001	0.0001	0.0001	0.0000	0.0000
38	0.0023	0.0006	0.0001	0.0001	0.0000	0.0000	0.0000
39	0.0020	0.0005	0.0001	0.0001	0.0000	0.0000	0.0000
40	0.0017	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000
41	0.0015	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000
42	0.0013	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000
43	0.0012	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000
44	0.0010	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000
45	0.0009	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000

Day	Dose Range*						
	$\leq 10^2$ spores	$10^2 < - \leq 10^3$ spores	$10^3 < - \leq 10^4$ spores	$10^4 < - \leq 10^5$ spores	$10^5 < - \leq 10^6$ spores	$10^6 < - \leq 10^7$ spores	$>10^7$ spores
46	0.0008	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
47	0.0007	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
48	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
49	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
50	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
51	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
52	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
53	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
54	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
55	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
56	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
57	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
58	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
59	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
60	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
61	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
62	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
63	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
64	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
65	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
66	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
67	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
68	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
69	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
70	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
71	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
72	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
73	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
≥74	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

* Table values were calculated using the upper dose specified in each column heading, with the exception of the last column, which used $2 \cdot 10^7$ spores; each column is to be used for the range of inhaled doses specified in the column heading.

Table 5-13: Daily Fraction of Stage 1 Treated Anthrax Survivors ($S_{DR,T-1}$) Who Become CONV

Day	Dose Range*						
	$\leq 10^2$ spores	$10^2 < - \leq 10^3$ spores	$10^3 < - \leq 10^4$ spores	$10^4 < - \leq 10^5$ spores	$10^5 < - \leq 10^6$ spores	$10^6 < - \leq 10^7$ spores	$>10^7$ spores
12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
13	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
14	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0014
15	0.0000	0.0000	0.0000	0.0001	0.0005	0.0099	0.0234
16	0.0005	0.0005	0.0007	0.0017	0.0082	0.0584	0.0903
17	0.0028	0.0034	0.0053	0.0120	0.0420	0.1348	0.1618
18	0.0096	0.0124	0.0196	0.0407	0.1031	0.1821	0.1873
19	0.0219	0.0291	0.0454	0.0845	0.1567	0.1790	0.1672
20	0.0380	0.0509	0.0766	0.1251	0.1737	0.1448	0.1273
21	0.0543	0.0721	0.1030	0.1460	0.1557	0.1038	0.0878
22	0.0675	0.0878	0.1175	0.1435	0.1209	0.0690	0.0570
23	0.0758	0.0956	0.1186	0.1243	0.0852	0.0438	0.0357
24	0.0791	0.0958	0.1094	0.0982	0.0564	0.0272	0.0221
25	0.0780	0.0903	0.0941	0.0724	0.0359	0.0167	0.0136
26	0.0737	0.0811	0.0769	0.0508	0.0224	0.0103	0.0084
27	0.0676	0.0704	0.0604	0.0344	0.0138	0.0065	0.0053
28	0.0605	0.0594	0.0461	0.0227	0.0086	0.0041	0.0034
29	0.0532	0.0492	0.0344	0.0148	0.0054	0.0027	0.0022
30	0.0462	0.0402	0.0253	0.0096	0.0035	0.0018	0.0015
31	0.0398	0.0324	0.0184	0.0062	0.0023	0.0012	0.0010
32	0.0340	0.0260	0.0133	0.0040	0.0015	0.0009	0.0007
33	0.0290	0.0207	0.0095	0.0026	0.0010	0.0006	0.0005
34	0.0246	0.0165	0.0068	0.0018	0.0007	0.0004	0.0004
35	0.0209	0.0131	0.0049	0.0012	0.0005	0.0003	0.0003
36	0.0177	0.0104	0.0035	0.0008	0.0004	0.0003	0.0002
37	0.0150	0.0083	0.0026	0.0006	0.0003	0.0002	0.0002
38	0.0127	0.0066	0.0019	0.0004	0.0002	0.0002	0.0002
39	0.0108	0.0053	0.0014	0.0003	0.0002	0.0001	0.0002
40	0.0092	0.0042	0.0010	0.0002	0.0001	0.0001	0.0001
41	0.0078	0.0034	0.0007	0.0002	0.0001	0.0001	0.0001
42	0.0067	0.0027	0.0006	0.0001	0.0001	0.0001	0.0001
43	0.0057	0.0022	0.0004	0.0001	0.0001	0.0001	0.0001
44	0.0049	0.0018	0.0003	0.0001	0.0001	0.0001	0.0001
45	0.0042	0.0014	0.0002	0.0001	0.0001	0.0001	0.0001
46	0.0036	0.0012	0.0002	0.0001	0.0001	0.0000	0.0000
47	0.0031	0.0010	0.0001	0.0001	0.0001	0.0000	0.0000
48	0.0027	0.0008	0.0001	0.0001	0.0001	0.0000	0.0000
49	0.0023	0.0006	0.0001	0.0001	0.0000	0.0000	0.0000
50	0.0020	0.0005	0.0001	0.0001	0.0000	0.0000	0.0000
51	0.0017	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000
52	0.0015	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000
53	0.0013	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000
54	0.0012	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000
55	0.0010	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000
56	0.0009	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000

Day	Dose Range*						
	$\leq 10^2$ spores	$10^2 < - \leq 10^3$ spores	$10^3 < - \leq 10^4$ spores	$10^4 < - \leq 10^5$ spores	$10^5 < - \leq 10^6$ spores	$10^6 < - \leq 10^7$ spores	$>10^7$ spores
57	0.0008	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
58	0.0007	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
59	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
60	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
61	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
62	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
63	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
64	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
65	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
66	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
67	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
68	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
69	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
70	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
71	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
72	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
73	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
74	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
75	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
76	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
77	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
78	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
79	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
80	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
81	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
82	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
83	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
84	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
≥85	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

* Table values were calculated using the upper dose specified in each column heading, with the exception of the last column, which used $2 \cdot 10^7$ spores; each column is to be used for the range of inhaled doses specified in the column heading.

Table 5-14: Daily Fraction of Stage 1 Treated Anthrax Survivors ($S_{DR,T-1}$) Who Become RTD

Day	Dose Range*						
	$\leq 10^2$ spores	$10^2 < - \leq 10^3$ spores	$10^3 < - \leq 10^4$ spores	$10^4 < - \leq 10^5$ spores	$10^5 < - \leq 10^6$ spores	$10^6 < - \leq 10^7$ spores	$>10^7$ spores
72	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
73	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
74	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0014
75	0.0000	0.0000	0.0000	0.0001	0.0005	0.0099	0.0234
76	0.0005	0.0005	0.0007	0.0017	0.0082	0.0584	0.0903
77	0.0028	0.0034	0.0053	0.0120	0.0420	0.1348	0.1618
78	0.0096	0.0124	0.0196	0.0407	0.1031	0.1821	0.1873
79	0.0219	0.0291	0.0454	0.0845	0.1567	0.1790	0.1672
80	0.0380	0.0509	0.0766	0.1251	0.1737	0.1448	0.1273
81	0.0543	0.0721	0.1030	0.1460	0.1557	0.1038	0.0878
82	0.0675	0.0878	0.1175	0.1435	0.1209	0.0690	0.0570
83	0.0758	0.0956	0.1186	0.1243	0.0852	0.0438	0.0357
84	0.0791	0.0958	0.1094	0.0982	0.0564	0.0272	0.0221
85	0.0780	0.0903	0.0941	0.0724	0.0359	0.0167	0.0136
86	0.0737	0.0811	0.0769	0.0508	0.0224	0.0103	0.0084
87	0.0676	0.0704	0.0604	0.0344	0.0138	0.0065	0.0053
88	0.0605	0.0594	0.0461	0.0227	0.0086	0.0041	0.0034
89	0.0532	0.0492	0.0344	0.0148	0.0054	0.0027	0.0022
90	0.0462	0.0402	0.0253	0.0096	0.0035	0.0018	0.0015
91	0.0398	0.0324	0.0184	0.0062	0.0023	0.0012	0.0010
92	0.0340	0.0260	0.0133	0.0040	0.0015	0.0009	0.0007
93	0.0290	0.0207	0.0095	0.0026	0.0010	0.0006	0.0005
94	0.0246	0.0165	0.0068	0.0018	0.0007	0.0004	0.0004
95	0.0209	0.0131	0.0049	0.0012	0.0005	0.0003	0.0003
96	0.0177	0.0104	0.0035	0.0008	0.0004	0.0003	0.0002
97	0.0150	0.0083	0.0026	0.0006	0.0003	0.0002	0.0002
98	0.0127	0.0066	0.0019	0.0004	0.0002	0.0002	0.0002
99	0.0108	0.0053	0.0014	0.0003	0.0002	0.0001	0.0002
100	0.0092	0.0042	0.0010	0.0002	0.0001	0.0001	0.0001
101	0.0078	0.0034	0.0007	0.0002	0.0001	0.0001	0.0001
102	0.0067	0.0027	0.0006	0.0001	0.0001	0.0001	0.0001
103	0.0057	0.0022	0.0004	0.0001	0.0001	0.0001	0.0001
104	0.0049	0.0018	0.0003	0.0001	0.0001	0.0001	0.0001
105	0.0042	0.0014	0.0002	0.0001	0.0001	0.0001	0.0001
106	0.0036	0.0012	0.0002	0.0001	0.0001	0.0000	0.0000
107	0.0031	0.0010	0.0001	0.0001	0.0001	0.0000	0.0000
108	0.0027	0.0008	0.0001	0.0001	0.0001	0.0000	0.0000
109	0.0023	0.0006	0.0001	0.0001	0.0000	0.0000	0.0000
110	0.0020	0.0005	0.0001	0.0001	0.0000	0.0000	0.0000
111	0.0017	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000
112	0.0015	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000
113	0.0013	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000
114	0.0012	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000
115	0.0010	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000
116	0.0009	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000

Day	Dose Range*						
	$\leq 10^2$ spores	$10^2 < - \leq 10^3$ spores	$10^3 < - \leq 10^4$ spores	$10^4 < - \leq 10^5$ spores	$10^5 < - \leq 10^6$ spores	$10^6 < - \leq 10^7$ spores	$>10^7$ spores
117	0.0008	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
118	0.0007	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
119	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
120	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
121	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
122	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
123	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
124	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
125	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
126	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
127	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
128	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
129	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
130	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
131	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
132	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
133	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
134	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
135	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
136	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
137	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
138	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
139	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
140	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
141	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
142	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
143	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
144	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
≥145	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

* Table values were calculated using the upper dose specified in each column heading, with the exception of the last column, which used $2 \cdot 10^7$ spores; each column is to be used for the range of inhaled doses specified in the column heading.

Table 5-15: Daily Fraction of Stage 2 Treated Anthrax Non-Survivors ($F_{DR,T-2}$) Who DOW

Day	Dose Range*						
	$\leq 10^2$ spores	$10^2 < - \leq 10^3$ spores	$10^3 < - \leq 10^4$ spores	$10^4 < - \leq 10^5$ spores	$10^5 < - \leq 10^6$ spores	$10^6 < - \leq 10^7$ spores	$>10^7$ spores
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0027
3	0.0001	0.0000	0.0001	0.0001	0.0009	0.0212	0.0480
4	0.0009	0.0010	0.0015	0.0034	0.0166	0.1020	0.1408
5	0.0051	0.0063	0.0098	0.0220	0.0721	0.1768	0.1908
6	0.0150	0.0197	0.0312	0.0631	0.1416	0.1893	0.1803
7	0.0302	0.0405	0.0627	0.1108	0.1759	0.1592	0.1418
8	0.0472	0.0632	0.0933	0.1420	0.1667	0.1176	0.1010
9	0.0621	0.0819	0.1133	0.1476	0.1342	0.0810	0.0682
10	0.0726	0.0930	0.1194	0.1330	0.0978	0.0537	0.0447
11	0.0778	0.0961	0.1137	0.1085	0.0672	0.0349	0.0289
12	0.0785	0.0928	0.1006	0.0825	0.0445	0.0224	0.0185
13	0.0755	0.0851	0.0841	0.0597	0.0290	0.0144	0.0119
14	0.0703	0.0751	0.0676	0.0418	0.0187	0.0093	0.0077
15	0.0637	0.0644	0.0526	0.0285	0.0120	0.0060	0.0050
16	0.0566	0.0540	0.0400	0.0191	0.0078	0.0039	0.0032
17	0.0496	0.0445	0.0299	0.0127	0.0050	0.0026	0.0021
18	0.0430	0.0363	0.0221	0.0084	0.0033	0.0017	0.0014
19	0.0370	0.0293	0.0161	0.0055	0.0022	0.0011	0.0010
20	0.0316	0.0235	0.0117	0.0037	0.0014	0.0008	0.0006
21	0.0269	0.0188	0.0084	0.0024	0.0010	0.0005	0.0004
22	0.0229	0.0150	0.0061	0.0016	0.0006	0.0004	0.0003
23	0.0194	0.0119	0.0044	0.0011	0.0004	0.0002	0.0002
24	0.0164	0.0095	0.0031	0.0007	0.0003	0.0002	0.0001
25	0.0139	0.0075	0.0023	0.0005	0.0002	0.0001	0.0001
26	0.0118	0.0060	0.0016	0.0003	0.0001	0.0001	0.0001
27	0.0100	0.0048	0.0012	0.0002	0.0001	0.0001	0.0001
28	0.0085	0.0038	0.0008	0.0002	0.0001	0.0000	0.0000
29	0.0073	0.0030	0.0006	0.0001	0.0001	0.0000	0.0000
30	0.0062	0.0024	0.0004	0.0001	0.0001	0.0000	0.0000
31	0.0053	0.0020	0.0003	0.0001	0.0001	0.0000	0.0000
32	0.0045	0.0016	0.0002	0.0001	0.0000	0.0000	0.0000
33	0.0039	0.0013	0.0002	0.0001	0.0000	0.0000	0.0000
34	0.0033	0.0010	0.0001	0.0001	0.0000	0.0000	0.0000
35	0.0029	0.0008	0.0001	0.0000	0.0000	0.0000	0.0000
36	0.0025	0.0007	0.0001	0.0000	0.0000	0.0000	0.0000
37	0.0021	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000
38	0.0019	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000
39	0.0016	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000
40	0.0014	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000
41	0.0012	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000
42	0.0011	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
43	0.0009	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
44	0.0008	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
45	0.0007	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000

Day	Dose Range*						
	$\leq 10^2$ spores	$10^2 < - \leq 10^3$ spores	$10^3 < - \leq 10^4$ spores	$10^4 < - \leq 10^5$ spores	$10^5 < - \leq 10^6$ spores	$10^6 < - \leq 10^7$ spores	$>10^7$ spores
46	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
47	0.0006	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
48	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
49	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
50	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
51	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
52	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
53	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
54	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
55	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
56	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
57	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
58	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
59	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
60	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
61	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
62	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
63	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
64	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
65	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
66	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
67	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
68	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
69	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
70	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
71	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
72	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
≥73	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

* Table values were calculated using the upper dose specified in each column heading, with the exception of the last column, which used $2 \cdot 10^7$ spores; each column is to be used for the range of inhaled doses specified in the column heading.

Figure 5-3: Human Response and Casualty Estimation for Anthrax

5.2.2. Brucellosis

1. Figure 5-4 summarizes the human response and casualty estimation processes for brucellosis, Table 5-16 summarizes the Injury Profile, and Table 5-17 summarizes the other brucellosis submodels. No prophylaxis is modeled for brucellosis.

2. Cohorts and special considerations.

   a. Brucellosis does not cause any fatalities, so there is no F cohort.

   b. Brucellosis has two distinct clinical presentations, abrupt and insidious onset, characterized by differences in the length of the incubation period, the Injury Severity Level, and the duration of illness. It is assumed that half of all cases are abrupt and the other half are insidious. Thus, the E cohort is split among an abrupt onset survivor cohort and an insidious onset survivor cohort according to Equation 5-36,

$$S_{ins,X} = S_{abr,Y} = 0.5 \cdot E, \tag{5-36}$$

   where the values of X and Y depend on $Flag_{MT}$ and the casualty criterion.

      1) If $Flag_{MT}$ = No, X and Y become “U”, for untreated.

      2) If $Flag_{MT}$ = Yes and the casualty criterion is WIA(1^+), X becomes “T-1”, for treated in Stage 1, and Y becomes “T”, for treated.

      3) If $Flag_{MT}$ = Yes and the casualty criterion is WIA(2^+) or WIA(3^+), X becomes “T-2”, for treated in Stage 2, and Y becomes “T”, for treated.

3. Assumptions and constraints.

   a. Assumptions.

      1) The presentation and duration of brucellosis symptoms are independent of the route of exposure.

      2) Half of all cases are abrupt, and the other half are insidious.

      3) One organism, one cell, and one CFU are equivalent.

      4) When $Flag_{MT}$ = Yes, WIAs begin receiving treatment on the first day they are declared WIA.

   b. Constraint. The models apply to *B. abortus*, *B. melitensis*, and *B. suis*.

4. Table 5-18 through Table 5-21 are the PDTs for brucellosis. The values from a given table are to be used in Equation 5-5 or 5-6 with the cohort(s) listed in the table header.

Table 5-16: Brucellosis Injury Profile

Stage	Injury Severity Level
Abrupt Onset Brucellosis ($S_{abr,Y}$)	
1	3
Insidious Onset Brucellosis ($S_{ins,X}$)	
1	1
2	3

Table 5-17: Brucellosis Submodel Summary

Type	Parameter Values (basis of derived values)
Infectivity ($p_E(X^{eff}_{brucellosis,n})$)	
Lognormal Distribution	μ = 6.855; σ = 0.892 (ID_{50} = 949 organisms; probit slope = 2.58 probits/log(dose))
Lethality (p_T(brucellosis))	
CFR	0%
Incubation Period*	
Weibull Distribution	α = 1.72; β = 10.2; (mean = 9.09 weeks; standard deviation = 5.45 weeks)
Duration of Illness*	
Total Duration: Untreated ($S_{ins,U}$) Stage 1: Abrupt Onset, Untreated ($S_{abr,Y}$)	
Gamma Distribution	k = 3.97; θ = 2.54 (mean = 10.1 weeks; standard deviation = 5.05 weeks)
Stage 1: Insidious Onset, Untreated ($S_{ins,U}$) Stage 1: Insidious Onset, Treatment Initiated in Stage 2 ($S_{ins,U}$)	
Gamma Distribution	k = 0.827; θ = 5.32 (mean = 4.41 weeks; standard deviation = 4.84 weeks)
Stage 2: Insidious Onset, Untreated ($S_{ins,U}$)	
Difference between (Total Duration, Untreated) and (Stage 1, Insidious Onset, Untreated)	
Stage 1: Abrupt Onset, Treated ($S_{abr,T}$) Total Duration: Insidious Onset, Treatment Initiated in Stage 1 ($S_{ins,T-1}$) Stage 2: Insidious Onset, Treatment Initiated in Stage 2 ($S_{ins,T-2}$)	
Constant	14 days

* Presented for information only. These two submodels have already been convolved to generate the PDTs; the user should use the PDTs to estimate when changes in casualty category occur.

† The distribution for the end of Stage 2, Insidious Onset, Untreated is the same as for the end of Stage 1, Abrupt Onset, Untreated. This has no effect on the casualty estimate because CONV and RTD are not estimated when medical treatment is not considered.

Table 5-18: Daily Fraction of Individuals Ill with Insidious Onset Brucellosis ($S_{ins,X}$) Who Become WIA, for Casualty Criterion WIA(1^+); Daily Fraction of Individuals Ill with Abrupt Onset Brucellosis ($S_{abr,Y}$) Who Become WIA, for any Casualty Criterion

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.00065	44	0.01101	87	0.00688	130	0.00228	173	0.00048
2	0.00148	45	0.01100	88	0.00675	131	0.00221	174	0.00046
3	0.00215	46	0.01099	89	0.00662	132	0.00214	175	0.00044
4	0.00273	47	0.01097	90	0.00649	133	0.00208	176	0.00042
5	0.00326	48	0.01094	91	0.00635	134	0.00201	177	0.00040
6	0.00376	49	0.01090	92	0.00622	135	0.00195	178	0.00039
7	0.00422	50	0.01086	93	0.00609	136	0.00188	179	0.00037
8	0.00466	51	0.01082	94	0.00596	137	0.00182	180	0.00035
9	0.00507	52	0.01077	95	0.00584	138	0.00176	181	0.00034
10	0.00546	53	0.01071	96	0.00571	139	0.00170	182	0.00033
11	0.00584	54	0.01065	97	0.00558	140	0.00165	183	0.00031
12	0.00619	55	0.01058	98	0.00546	141	0.00159	184	0.00030
13	0.00653	56	0.01051	99	0.00533	142	0.00154	185	0.00029
14	0.00686	57	0.01043	100	0.00521	143	0.00149	186	0.00027
15	0.00717	58	0.01035	101	0.00509	144	0.00144	187	0.00026
16	0.00746	59	0.01026	102	0.00497	145	0.00139	188	0.00025
17	0.00774	60	0.01017	103	0.00485	146	0.00134	189	0.00024
18	0.00801	61	0.01008	104	0.00474	147	0.00129	190	0.00023
19	0.00826	62	0.00998	105	0.00462	148	0.00125	191	0.00022
20	0.00850	63	0.00988	106	0.00451	149	0.00120	192	0.00021
21	0.00873	64	0.00978	107	0.00440	150	0.00116	193	0.00020
22	0.00894	65	0.00967	108	0.00428	151	0.00112	194	0.00019
23	0.00914	66	0.00956	109	0.00418	152	0.00108	195	0.00018
24	0.00933	67	0.00945	110	0.00407	153	0.00104	196–197	0.00017
25	0.00951	68	0.00933	111	0.00396	154	0.00100	198	0.00016
26	0.00968	69	0.00921	112	0.00386	155	0.00097	199	0.00015
27	0.00984	70	0.00909	113	0.00376	156	0.00093	200–201	0.00014
28	0.00998	71	0.00897	114	0.00366	157	0.00090	202–203	0.00013
29	0.01012	72	0.00885	115	0.00356	158	0.00086	204	0.00012
30	0.01024	73	0.00872	116	0.00346	159	0.00083	205–206	0.00011
31	0.01036	74	0.00860	117	0.00336	160	0.00080	207–208	0.00010
32	0.01046	75	0.00847	118	0.00327	161	0.00077	209–211	0.00009
33	0.01056	76	0.00834	119	0.00318	162	0.00074	212–213	0.00008
34	0.01064	77	0.00821	120	0.00309	163	0.00071	214–216	0.00007
35	0.01072	78	0.00808	121	0.00300	164	0.00068	217–219	0.00006
36	0.01078	79	0.00795	122	0.00291	165	0.00066	220–223	0.00005
37	0.01084	80	0.00782	123	0.00283	166	0.00063	224–228	0.00004
38	0.01089	81	0.00768	124	0.00275	167	0.00061	229–234	0.00003
39	0.01093	82	0.00755	125	0.00266	168	0.00058	235–244	0.00002
40	0.01096	83	0.00742	126	0.00258	169	0.00056	245–266	0.00001
41	0.01098	84	0.00728	127	0.00251	170	0.00054	≥267	0.00000
42	0.01100	85	0.00715	128	0.00243	171	0.00052		
43	0.01101	86	0.00702	129	0.00236	172	0.00050		

Table 5-19: Daily Fraction of Individuals Ill with Insidious Onset Brucellosis ($S_{ins,X}$) Who Become WIA, for Casualty Criterion WIA(2^+) or WIA(3^+)

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.00001	56	0.00811	111	0.00643	166	0.00233	221	0.00059
2	0.00007	57	0.00818	112	0.00634	167	0.00228	222	0.00057
3	0.00015	58	0.00824	113	0.00626	168	0.00223	223	0.00056
4	0.00025	59	0.00829	114	0.00617	169	0.00218	224	0.00054
5	0.00036	60	0.00834	115	0.00609	170	0.00213	225	0.00053
6	0.00049	61	0.00839	116	0.00600	171	0.00208	226	0.00051
7	0.00063	62	0.00843	117	0.00591	172	0.00203	227	0.00050
8	0.00078	63	0.00846	118	0.00583	173	0.00198	228	0.00049
9	0.00093	64	0.00850	119	0.00574	174	0.00194	229	0.00047
10	0.00109	65	0.00852	120	0.00566	175	0.00189	230	0.00046
11	0.00126	66	0.00855	121	0.00557	176	0.00185	231	0.00045
12	0.00144	67	0.00856	122	0.00549	177	0.00180	232	0.00044
13	0.00161	68	0.00858	123	0.00540	178	0.00176	233	0.00042
14	0.00180	69	0.00859	124	0.00531	179	0.00172	234	0.00041
15	0.00198	70	0.00859	125	0.00523	180	0.00168	235	0.00040
16	0.00217	71	0.00860	126	0.00514	181	0.00164	236	0.00039
17	0.00236	72	0.00859	127	0.00506	182	0.00160	237	0.00038
18	0.00255	73	0.00859	128	0.00498	183	0.00156	238	0.00037
19	0.00274	74	0.00858	129	0.00489	184	0.00152	239	0.00036
20	0.00294	75	0.00857	130	0.00481	185	0.00149	240	0.00035
21	0.00313	76	0.00855	131	0.00473	186	0.00145	241	0.00034
22	0.00332	77	0.00853	132	0.00465	187	0.00141	242	0.00033
23	0.00352	78	0.00851	133	0.00456	188	0.00138	243	0.00032
24	0.00371	79	0.00848	134	0.00448	189	0.00135	244–245	0.00031
25	0.00390	80	0.00845	135	0.00440	190	0.00131	246	0.00030
26	0.00409	81	0.00842	136	0.00432	191	0.00128	247	0.00029
27	0.00427	82	0.00838	137	0.00424	192	0.00125	248	0.00028
28	0.00446	83	0.00834	138	0.00417	193	0.00122	249–250	0.00027
29	0.00464	84	0.00830	139	0.00409	194	0.00119	251	0.00026
30	0.00482	85	0.00825	140	0.00401	195	0.00116	252	0.00025
31	0.00500	86	0.00821	141	0.00394	196	0.00113	253–254	0.00024
32	0.00517	87	0.00815	142	0.00386	197	0.00110	255–256	0.00023
33	0.00534	88	0.00810	143	0.00379	198	0.00107	257	0.00022
34	0.00551	89	0.00805	144	0.00371	199	0.00105	258–259	0.00021
35	0.00568	90	0.00799	145	0.00364	200	0.00102	260–261	0.00020
36	0.00584	91	0.00793	146	0.00357	201	0.00099	262–263	0.00019
37	0.00599	92	0.00787	147	0.00350	202	0.00097	264–265	0.00018
38	0.00614	93	0.00781	148	0.00343	203	0.00094	266–267	0.00017
39	0.00629	94	0.00774	149	0.00336	204	0.00092	268–269	0.00016
40	0.00644	95	0.00767	150	0.00329	205	0.00090	270–271	0.00015
41	0.00658	96	0.00761	151	0.00323	206	0.00087	272–274	0.00014
42	0.00671	97	0.00754	152	0.00316	207	0.00085	275–277	0.00013
43	0.00684	98	0.00746	153	0.00309	208	0.00083	278–280	0.00012
44	0.00697	99	0.00739	154	0.00303	209	0.00081	281–283	0.00011
45	0.00709	100	0.00732	155	0.00297	210	0.00079	284–287	0.00010
46	0.00721	101	0.00724	156	0.00290	211	0.00077	288–291	0.00009
47	0.00732	102	0.00716	157	0.00284	212	0.00075	292–295	0.00008

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
48	0.00743	103	0.00708	158	0.00278	213	0.00073	296–300	0.00007
49	0.00753	104	0.00700	159	0.00272	214	0.00071	301–306	0.00006
50	0.00763	105	0.00692	160	0.00266	215	0.00069	307–313	0.00005
51	0.00772	106	0.00684	161	0.00260	216	0.00067	314–322	0.00004
52	0.00781	107	0.00676	162	0.00255	217	0.00065	323–335	0.00003
53	0.00789	108	0.00668	163	0.00249	218	0.00064	336–353	0.00002
54	0.00797	109	0.00660	164	0.00244	219	0.00062	354–404	0.00001
55	0.00805	110	0.00651	165	0.00238	220	0.00060	≥405	0.00000

Table 5-20: Daily Fraction of Stage 1 Treated Insidious Onset Brucellosis Survivors ($S_{ins,T-1}$) and Treated Abrupt Onset Brucellosis Survivors ($S_{abr,T}$) Who Become CONV

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
15	0.00065	58	0.01101	101	0.00688	144	0.00228	187	0.00048
16	0.00148	59	0.01100	102	0.00675	145	0.00221	188	0.00046
17	0.00215	60	0.01099	103	0.00662	146	0.00214	189	0.00044
18	0.00273	61	0.01097	104	0.00649	147	0.00208	190	0.00042
19	0.00326	62	0.01094	105	0.00635	148	0.00201	191	0.00040
20	0.00376	63	0.01090	106	0.00622	149	0.00195	192	0.00039
21	0.00422	64	0.01086	107	0.00609	150	0.00188	193	0.00037
22	0.00466	65	0.01082	108	0.00596	151	0.00182	194	0.00035
23	0.00507	66	0.01077	109	0.00584	152	0.00176	195	0.00034
24	0.00546	67	0.01071	110	0.00571	153	0.00170	196	0.00033
25	0.00584	68	0.01065	111	0.00558	154	0.00165	197	0.00031
26	0.00619	69	0.01058	112	0.00546	155	0.00159	198	0.00030
27	0.00653	70	0.01051	113	0.00533	156	0.00154	199	0.00029
28	0.00686	71	0.01043	114	0.00521	157	0.00149	200	0.00027
29	0.00717	72	0.01035	115	0.00509	158	0.00144	201	0.00026
30	0.00746	73	0.01026	116	0.00497	159	0.00139	202	0.00025
31	0.00774	74	0.01017	117	0.00485	160	0.00134	203	0.00024
32	0.00801	75	0.01008	118	0.00474	161	0.00129	204	0.00023
33	0.00826	76	0.00998	119	0.00462	162	0.00125	205	0.00022
34	0.00850	77	0.00988	120	0.00451	163	0.00120	206	0.00021
35	0.00873	78	0.00978	121	0.00440	164	0.00116	207	0.00020
36	0.00894	79	0.00967	122	0.00428	165	0.00112	208	0.00019
37	0.00914	80	0.00956	123	0.00418	166	0.00108	209	0.00018
38	0.00933	81	0.00945	124	0.00407	167	0.00104	210–211	0.00017
39	0.00951	82	0.00933	125	0.00396	168	0.00100	212	0.00016
40	0.00968	83	0.00921	126	0.00386	169	0.00097	213	0.00015
41	0.00984	84	0.00909	127	0.00376	170	0.00093	214–215	0.00014
42	0.00998	85	0.00897	128	0.00366	171	0.00090	216–217	0.00013
43	0.01012	86	0.00885	129	0.00356	172	0.00086	218	0.00012
44	0.01024	87	0.00872	130	0.00346	173	0.00083	219–220	0.00011
45	0.01036	88	0.00860	131	0.00336	174	0.00080	221–222	0.00010
46	0.01046	89	0.00847	132	0.00327	175	0.00077	223–225	0.00009
47	0.01056	90	0.00834	133	0.00318	176	0.00074	226–227	0.00008
48	0.01064	91	0.00821	134	0.00309	177	0.00071	228–230	0.00007
49	0.01072	92	0.00808	135	0.00300	178	0.00068	231–233	0.00006
50	0.01078	93	0.00795	136	0.00291	179	0.00066	234–237	0.00005

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
51	0.01084	94	0.00782	137	0.00283	180	0.00063	238–242	0.00004
52	0.01089	95	0.00768	138	0.00275	181	0.00061	243–248	0.00003
53	0.01093	96	0.00755	139	0.00266	182	0.00058	249–258	0.00002
54	0.01096	97	0.00742	140	0.00258	183	0.00056	259–280	0.00001
55	0.01098	98	0.00728	141	0.00251	184	0.00054	≥281	0.00000
56	0.01100	99	0.00715	142	0.00243	185	0.00052		
57	0.01101	100	0.00702	143	0.00236	186	0.00050		

Table 5-21: Daily Fraction of Stage 2 Treated Insidious Onset Brucellosis Survivors ($S_{ins,T-2}$) Who Become CONV

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
15	0.00001	70	0.00811	125	0.00643	180	0.00233	235	0.00059
16	0.00007	71	0.00818	126	0.00634	181	0.00228	236	0.00057
17	0.00015	72	0.00824	127	0.00626	182	0.00223	237	0.00056
18	0.00025	73	0.00829	128	0.00617	183	0.00218	238	0.00054
19	0.00036	74	0.00834	129	0.00609	184	0.00213	239	0.00053
20	0.00049	75	0.00839	130	0.00600	185	0.00208	240	0.00051
21	0.00063	76	0.00843	131	0.00591	186	0.00203	241	0.00050
22	0.00078	77	0.00846	132	0.00583	187	0.00198	242	0.00049
23	0.00093	78	0.00850	133	0.00574	188	0.00194	243	0.00047
24	0.00109	79	0.00852	134	0.00566	189	0.00189	244	0.00046
25	0.00126	80	0.00855	135	0.00557	190	0.00185	245	0.00045
26	0.00144	81	0.00856	136	0.00549	191	0.00180	246	0.00044
27	0.00161	82	0.00858	137	0.00540	192	0.00176	247	0.00042
28	0.00180	83	0.00859	138	0.00531	193	0.00172	248	0.00041
29	0.00198	84	0.00859	139	0.00523	194	0.00168	249	0.00040
30	0.00217	85	0.00860	140	0.00514	195	0.00164	250	0.00039
31	0.00236	86	0.00859	141	0.00506	196	0.00160	251	0.00038
32	0.00255	87	0.00859	142	0.00498	197	0.00156	252	0.00037
33	0.00274	88	0.00858	143	0.00489	198	0.00152	253	0.00036
34	0.00294	89	0.00857	144	0.00481	199	0.00149	254	0.00035
35	0.00313	90	0.00855	145	0.00473	200	0.00145	255	0.00034
36	0.00332	91	0.00853	146	0.00465	201	0.00141	256	0.00033
37	0.00352	92	0.00851	147	0.00456	202	0.00138	257	0.00032
38	0.00371	93	0.00848	148	0.00448	203	0.00135	258–259	0.00031
39	0.00390	94	0.00845	149	0.00440	204	0.00131	260	0.00030
40	0.00409	95	0.00842	150	0.00432	205	0.00128	261	0.00029
41	0.00427	96	0.00838	151	0.00424	206	0.00125	262	0.00028
42	0.00446	97	0.00834	152	0.00417	207	0.00122	263–264	0.00027
43	0.00464	98	0.00830	153	0.00409	208	0.00119	265	0.00026
44	0.00482	99	0.00825	154	0.00401	209	0.00116	266	0.00025
45	0.00500	100	0.00821	155	0.00394	210	0.00113	267–268	0.00024
46	0.00517	101	0.00815	156	0.00386	211	0.00110	269–270	0.00023
47	0.00534	102	0.00810	157	0.00379	212	0.00107	271	0.00022
48	0.00551	103	0.00805	158	0.00371	213	0.00105	272–273	0.00021
49	0.00568	104	0.00799	159	0.00364	214	0.00102	274–275	0.00020
50	0.00584	105	0.00793	160	0.00357	215	0.00099	276–277	0.00019
51	0.00599	106	0.00787	161	0.00350	216	0.00097	278–279	0.00018
52	0.00614	107	0.00781	162	0.00343	217	0.00094	280–281	0.00017

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
53	0.00629	108	0.00774	163	0.00336	218	0.00092	282–283	0.00016
54	0.00644	109	0.00767	164	0.00329	219	0.00090	284–285	0.00015
55	0.00658	110	0.00761	165	0.00323	220	0.00087	286–288	0.00014
56	0.00671	111	0.00754	166	0.00316	221	0.00085	289–291	0.00013
57	0.00684	112	0.00746	167	0.00309	222	0.00083	292–294	0.00012
58	0.00697	113	0.00739	168	0.00303	223	0.00081	295–297	0.00011
59	0.00709	114	0.00732	169	0.00297	224	0.00079	298–301	0.00010
60	0.00721	115	0.00724	170	0.00290	225	0.00077	302–305	0.00009
61	0.00732	116	0.00716	171	0.00284	226	0.00075	306–309	0.00008
62	0.00743	117	0.00708	172	0.00278	227	0.00073	310–314	0.00007
63	0.00753	118	0.00700	173	0.00272	228	0.00071	315–320	0.00006
64	0.00763	119	0.00692	174	0.00266	229	0.00069	321–327	0.00005
65	0.00772	120	0.00684	175	0.00260	230	0.00067	328–336	0.00004
66	0.00781	121	0.00676	176	0.00255	231	0.00065	337–349	0.00003
67	0.00789	122	0.00668	177	0.00249	232	0.00064	350–367	0.00002
68	0.00797	123	0.00660	178	0.00244	233	0.00062	368–418	0.00001
69	0.00805	124	0.00651	179	0.00238	234	0.00060	≥418	0.00000

Table 5-22: Daily Fraction of Stage 1 Treated Insidious Onset Brucellosis Survivors ($S_{ins,T-1}$) and Treated Abrupt Onset Brucellosis Survivors ($S_{abr,T}$) Who Become RTD

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
43	0.00065	86	0.01101	129	0.00688	172	0.00228	215	0.00048
44	0.00148	87	0.01100	130	0.00675	173	0.00221	216	0.00046
45	0.00215	88	0.01099	131	0.00662	174	0.00214	217	0.00044
46	0.00273	89	0.01097	132	0.00649	175	0.00208	218	0.00042
47	0.00326	90	0.01094	133	0.00635	176	0.00201	219	0.00040
48	0.00376	91	0.01090	134	0.00622	177	0.00195	220	0.00039
49	0.00422	92	0.01086	135	0.00609	178	0.00188	221	0.00037
50	0.00466	93	0.01082	136	0.00596	179	0.00182	222	0.00035
51	0.00507	94	0.01077	137	0.00584	180	0.00176	223	0.00034
52	0.00546	95	0.01071	138	0.00571	181	0.00170	224	0.00033
53	0.00584	96	0.01065	139	0.00558	182	0.00165	225	0.00031
54	0.00619	97	0.01058	140	0.00546	183	0.00159	226	0.00030
55	0.00653	98	0.01051	141	0.00533	184	0.00154	227	0.00029
56	0.00686	99	0.01043	142	0.00521	185	0.00149	228	0.00027
57	0.00717	100	0.01035	143	0.00509	186	0.00144	229	0.00026
58	0.00746	101	0.01026	144	0.00497	187	0.00139	230	0.00025
59	0.00774	102	0.01017	145	0.00485	188	0.00134	231	0.00024
60	0.00801	103	0.01008	146	0.00474	189	0.00129	232	0.00023
61	0.00826	104	0.00998	147	0.00462	190	0.00125	233	0.00022
62	0.00850	105	0.00988	148	0.00451	191	0.00120	234	0.00021
63	0.00873	106	0.00978	149	0.00440	192	0.00116	235	0.00020
64	0.00894	107	0.00967	150	0.00428	193	0.00112	236	0.00019
65	0.00914	108	0.00956	151	0.00418	194	0.00108	237	0.00018
66	0.00933	109	0.00945	152	0.00407	195	0.00104	238–239	0.00017
67	0.00951	110	0.00933	153	0.00396	196	0.00100	240	0.00016
68	0.00968	111	0.00921	154	0.00386	197	0.00097	241	0.00015
69	0.00984	112	0.00909	155	0.00376	198	0.00093	242–243	0.00014

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
70	0.00998	113	0.00897	156	0.00366	199	0.00090	244–245	0.00013
71	0.01012	114	0.00885	157	0.00356	200	0.00086	246	0.00012
72	0.01024	115	0.00872	158	0.00346	201	0.00083	247–248	0.00011
73	0.01036	116	0.00860	159	0.00336	202	0.00080	249–250	0.00010
74	0.01046	117	0.00847	160	0.00327	203	0.00077	251–253	0.00009
75	0.01056	118	0.00834	161	0.00318	204	0.00074	254–255	0.00008
76	0.01064	119	0.00821	162	0.00309	205	0.00071	256–258	0.00007
77	0.01072	120	0.00808	163	0.00300	206	0.00068	259–261	0.00006
78	0.01078	121	0.00795	164	0.00291	207	0.00066	262–265	0.00005
79	0.01084	122	0.00782	165	0.00283	208	0.00063	266–270	0.00004
80	0.01089	123	0.00768	166	0.00275	209	0.00061	271–276	0.00003
81	0.01093	124	0.00755	167	0.00266	210	0.00058	277–287	0.00002
82	0.01096	125	0.00742	168	0.00258	211	0.00056	288–308	0.00001
83	0.01098	126	0.00728	169	0.00251	212	0.00054	≥309	0.00000
84	0.01100	127	0.00715	170	0.00243	213	0.00052		
85	0.01101	128	0.00702	171	0.00236	214	0.00050		

Table 5-23: Daily Fraction of Stage 2 Treated Insidious Onset Brucellosis Survivors ($S_{ins,T-2}$) Who Become RTD

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
43	0.00001	98	0.00811	153	0.00643	208	0.00233	263	0.00059
44	0.00007	99	0.00818	154	0.00634	209	0.00228	264	0.00057
45	0.00015	100	0.00824	155	0.00626	210	0.00223	265	0.00056
46	0.00025	101	0.00829	156	0.00617	211	0.00218	266	0.00054
47	0.00036	102	0.00834	157	0.00609	212	0.00213	267	0.00053
48	0.00049	103	0.00839	158	0.00600	213	0.00208	268	0.00051
49	0.00063	104	0.00843	159	0.00591	214	0.00203	269	0.00050
50	0.00078	105	0.00846	160	0.00583	215	0.00198	270	0.00049
51	0.00093	106	0.00850	161	0.00574	216	0.00194	271	0.00047
52	0.00109	107	0.00852	162	0.00566	217	0.00189	272	0.00046
53	0.00126	108	0.00855	163	0.00557	218	0.00185	273	0.00045
54	0.00144	109	0.00856	164	0.00549	219	0.00180	274	0.00044
55	0.00161	110	0.00858	165	0.00540	220	0.00176	275	0.00042
56	0.00180	111	0.00859	166	0.00531	221	0.00172	276	0.00041
57	0.00198	112	0.00859	167	0.00523	222	0.00168	277	0.00040
58	0.00217	113	0.00860	168	0.00514	223	0.00164	278	0.00039
59	0.00236	114	0.00859	169	0.00506	224	0.00160	279	0.00038
60	0.00255	115	0.00859	170	0.00498	225	0.00156	280	0.00037
61	0.00274	116	0.00858	171	0.00489	226	0.00152	281	0.00036
62	0.00294	117	0.00857	172	0.00481	227	0.00149	282	0.00035
63	0.00313	118	0.00855	173	0.00473	228	0.00145	283	0.00034
64	0.00332	119	0.00853	174	0.00465	229	0.00141	284	0.00033
65	0.00352	120	0.00851	175	0.00456	230	0.00138	285	0.00032
66	0.00371	121	0.00848	176	0.00448	231	0.00135	286–287	0.00031
67	0.00390	122	0.00845	177	0.00440	232	0.00131	288	0.00030
68	0.00409	123	0.00842	178	0.00432	233	0.00128	289	0.00029
69	0.00427	124	0.00838	179	0.00424	234	0.00125	290	0.00028
70	0.00446	125	0.00834	180	0.00417	235	0.00122	291–292	0.00027
71	0.00464	126	0.00830	181	0.00409	236	0.00119	293	0.00026

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
72	0.00482	127	0.00825	182	0.00401	237	0.00116	294	0.00025
73	0.00500	128	0.00821	183	0.00394	238	0.00113	295–296	0.00024
74	0.00517	129	0.00815	184	0.00386	239	0.00110	297–298	0.00023
75	0.00534	130	0.00810	185	0.00379	240	0.00107	299	0.00022
76	0.00551	131	0.00805	186	0.00371	241	0.00105	300–301	0.00021
77	0.00568	132	0.00799	187	0.00364	242	0.00102	302–303	0.00020
78	0.00584	133	0.00793	188	0.00357	243	0.00099	304–305	0.00019
79	0.00599	134	0.00787	189	0.00350	244	0.00097	306–307	0.00018
80	0.00614	135	0.00781	190	0.00343	245	0.00094	308–309	0.00017
81	0.00629	136	0.00774	191	0.00336	246	0.00092	310–311	0.00016
82	0.00644	137	0.00767	192	0.00329	247	0.00090	312–313	0.00015
83	0.00658	138	0.00761	193	0.00323	248	0.00087	314–316	0.00014
84	0.00671	139	0.00754	194	0.00316	249	0.00085	317–319	0.00013
85	0.00684	140	0.00746	195	0.00309	250	0.00083	320–322	0.00012
86	0.00697	141	0.00739	196	0.00303	251	0.00081	323–325	0.00011
87	0.00709	142	0.00732	197	0.00297	252	0.00079	326–329	0.00010
88	0.00721	143	0.00724	198	0.00290	253	0.00077	330–333	0.00009
89	0.00732	144	0.00716	199	0.00284	254	0.00075	334–337	0.00008
90	0.00743	145	0.00708	200	0.00278	255	0.00073	338–342	0.00007
91	0.00753	146	0.00700	201	0.00272	256	0.00071	343–348	0.00006
92	0.00763	147	0.00692	202	0.00266	257	0.00069	349–355	0.00005
93	0.00772	148	0.00684	203	0.00260	258	0.00067	356–364	0.00004
94	0.00781	149	0.00676	204	0.00255	259	0.00065	365–377	0.00003
95	0.00789	150	0.00668	205	0.00249	260	0.00064	378–395	0.00002
96	0.00797	151	0.00660	206	0.00244	261	0.00062	396–446	0.00001
97	0.00805	152	0.00651	207	0.00238	262	0.00060	≥446	0.00000

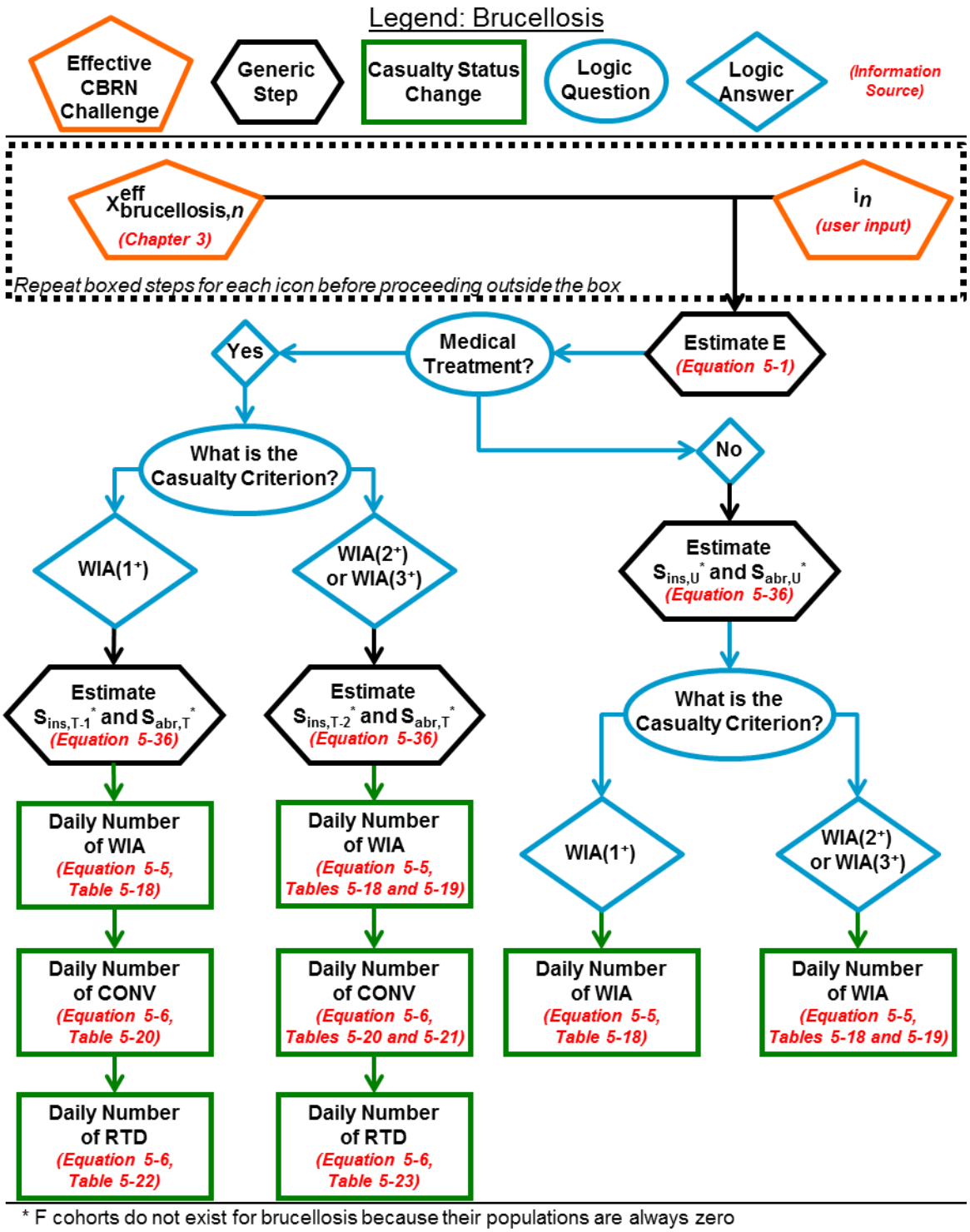


Figure 5-4: Human Response and Casualty Estimation for Brucellosis

5.2.3. Glanders

1. Figure 5-5 summarizes the human response and casualty estimation processes for glanders, Table 5-24 summarizes the Injury Profile, and Table 5-25 summarizes the other glanders submodels. No prophylaxis is modeled for glanders.

2. Cohorts and special considerations.

   a. If $Flag_{MT}$ = No, the population of the E cohort moves into F_U and S_U.

   b. $Flag_{MT}$ currently cannot be set to Yes for glanders; the treatment models for glanders are under development and will be included in Study Draft 3.

3. Assumption. Human response to *B. mallei* is independent of the route of exposure.

4. Table 5-26 through Table 5-29 are the PDTs for glanders. The values from a given table are to be used in Equation 5-5 or 5-6 with the cohort(s) listed in the table header.

Table 5-24: Glanders Injury Profile

Stage	Injury Severity Level
Untreated Glanders Survivors (S_U)	
1	1
2	2
3	3
4	4
Untreated Glanders Non-Survivors (F_U)	
1	1
2	2
3	3

Table 5-25: Glanders Submodel Summary

Type	Parameter Values (basis of derived values)
Infectivity ($p_F(X^{eff}_{glanders,n})$)	
Lognormal Distribution	μ = 3.199; σ = 1.193 (ID_{50} = 24.5 CFU; probit slope = 1.93 probits/log(dose))
Lethality (p_L(glanders))	
Untreated	
CFR	70%
Incubation Period*	
Lognormal Distribution	μ = 1.495; σ = 1.114 (mean = 8.29 days; standard deviation = 13.0 days)
Duration of Illness*	
Stage 1: Untreated (F_U and S_U)	
Weibull Distribution	α = 1.9; β = 7.8 (mean = 6.9 days; standard deviation = 3.8 days)
Stage 2: Untreated (F_U and S_U)	
Weibull Distribution	μ = 1.9; σ = 11.7 (mean = 10.4 days; standard deviation = 5.7 days)
Stage 3: Untreated (F_U and S_U)	
Weibull Distribution	μ = 1.9; σ = 6.5 (mean = 5.8 days; standard deviation = 3.2 days)

* Presented for information only. These two submodels have already been convolved to generate the PDTs; the user should use the PDTs to estimate when changes in casualty category occur.

Table 5-26: Daily Fraction of Individuals Ill with Glanders (E) Who Become WIA, for Casualty Criterion WIA(1+)

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.08986	20	0.00764	39	0.00143	58	0.00045	77	0.00018
2	0.14609	21	0.00684	40	0.00133	59	0.00042	78–79	0.00017
3	0.12519	22	0.00615	41	0.00124	60	0.00040	80	0.00016
4	0.10015	23	0.00554	42	0.00116	61	0.00038	81–82	0.00015
5	0.07978	24	0.00501	43	0.00109	62	0.00036	83	0.00014
6	0.06412	25	0.00454	44	0.00102	63	0.00035	84–85	0.00013
7	0.05214	26	0.00412	45	0.00095	64	0.00033	86–88	0.00012
8	0.04290	27	0.00376	46	0.00089	65	0.00031	89–90	0.00011
9	0.03568	28	0.00343	47	0.00084	66	0.00030	91–93	0.00010
10	0.02998	29	0.00314	48	0.00079	67	0.00028	94–96	0.00009
11	0.02541	30	0.00288	49	0.00074	68	0.00027	97–99	0.00008
12	0.02171	31	0.00265	50	0.00070	69	0.00026	100–103	0.00007
13	0.01869	32	0.00244	51	0.00066	70	0.00025	104–108	0.00006
14	0.01619	33	0.00225	52	0.00062	71	0.00024	109–114	0.00005
15	0.01411	34	0.00208	53	0.00059	72	0.00023	115–123	0.00004
16	0.01237	35	0.00192	54	0.00056	73	0.00022	124–134	0.00003
17	0.01089	36	0.00178	55	0.00053	74	0.00021	135–154	0.00002
18	0.00964	37	0.00165	56	0.00050	75	0.00020	155–225	0.00001
19	0.00857	38	0.00154	57	0.00047	76	0.00019	≥226	0.00000

Table 5-27: Daily Fraction of Individuals Ill with Glanders (E) Who Become WIA, for Casualty Criterion WIA(2+)

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.00032	22	0.01745	43	0.00188	64	0.00048	86	0.00017
2	0.00385	23	0.01510	44	0.00174	65	0.00046	87	0.00016
3	0.01181	24	0.01312	45	0.00161	66	0.00043	88–89	0.00015
4	0.02252	25	0.01145	46	0.00150	67	0.00041	90–91	0.00014
5	0.03411	26	0.01005	47	0.00139	68	0.00039	92–93	0.00013
6	0.04503	27	0.00885	48	0.00130	69	0.00037	94–95	0.00012
7	0.05416	28	0.00784	49	0.00121	70	0.00035	96–97	0.00011
8	0.06083	29	0.00697	50	0.00113	71	0.00034	98–100	0.00010
9	0.06476	30	0.00622	51	0.00106	72	0.00032	101–103	0.00009
10	0.06603	31	0.00558	52	0.00099	73	0.00030	104–106	0.00008
11	0.06495	32	0.00502	53	0.00093	74	0.00029	107–110	0.00007
12	0.06200	33	0.00453	54	0.00087	75	0.00028	111–115	0.00006
13	0.05770	34	0.00411	55	0.00082	76	0.00026	116–122	0.00005
14	0.05258	35	0.00373	56	0.00077	77	0.00025	123–130	0.00004
15	0.04710	36	0.00340	57	0.00072	78	0.00024	131–141	0.00003
16	0.04161	37	0.00310	58	0.00068	79	0.00023	142–161	0.00002
17	0.03637	38	0.00284	59	0.00064	80	0.00022	162–234	0.00001
18	0.03155	39	0.00260	60	0.00061	81	0.00021	≥235	0.00000
19	0.02724	40	0.00239	61	0.00057	82	0.00020		
20	0.02347	41	0.00220	62	0.00054	83	0.00019		
21	0.02022	42	0.00203	63	0.00051	84–85	0.00018		

Table 5-28: Daily Fraction of Individuals Ill with Glanders (E) Who Become WIA, for Casualty Criterion WIA(3+)

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.00000	24	0.04170	47	0.00412	70	0.00067	93	0.00020
2	0.00001	25	0.03981	48	0.00371	71	0.00063	94–95	0.00019
3	0.00010	26	0.03762	49	0.00336	72	0.00060	96	0.00018
4	0.00038	27	0.03522	50	0.00304	73	0.00056	97	0.00017
5	0.00101	28	0.03270	51	0.00277	74	0.00053	98–99	0.00016
6	0.00214	29	0.03012	52	0.00252	75	0.00050	100	0.00015
7	0.00386	30	0.02755	53	0.00231	76	0.00047	101–102	0.00014
8	0.00622	31	0.02505	54	0.00211	77	0.00045	103–104	0.00013
9	0.00921	32	0.02265	55	0.00194	78	0.00042	105–106	0.00012
10	0.01276	33	0.02038	56	0.00179	79	0.00040	107–108	0.00011
11	0.01673	34	0.01827	57	0.00165	80	0.00038	109–111	0.00010
12	0.02097	35	0.01632	58	0.00153	81	0.00036	112–114	0.00009
13	0.02528	36	0.01454	59	0.00141	82	0.00034	115–117	0.00008
14	0.02949	37	0.01294	60	0.00131	83	0.00033	118–122	0.00007
15	0.03340	38	0.01149	61	0.00122	84	0.00031	123–126	0.00006
16	0.03688	39	0.01021	62	0.00113	85	0.00030	127–133	0.00005
17	0.03979	40	0.00906	63	0.00106	86	0.00028	134–141	0.00004
18	0.04205	41	0.00805	64	0.00099	87	0.00027	142–152	0.00003
19	0.04362	42	0.00717	65	0.00092	88	0.00026	153–172	0.00002
20	0.04448	43	0.00639	66	0.00086	89	0.00024	173–249	0.00001
21	0.04466	44	0.00570	67	0.00081	90	0.00023	≥250	0.00000
22	0.04421	45	0.00510	68	0.00076	91	0.00022		

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
23	0.04320	46	0.00458	69	0.00071	92	0.00021		

Table 5-29: Daily Fraction of Glanders Non-Survivors (F_U) Who DOW

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.00000	25	0.04076	49	0.00674	73	0.00082	97	0.00022
2	0.00000	26	0.04147	50	0.00602	74	0.00077	98	0.00021
3	0.00000	27	0.04163	51	0.00538	75	0.00072	99	0.00020
4	0.00001	28	0.04128	52	0.00483	76	0.00068	100–101	0.00019
5	0.00004	29	0.04046	53	0.00433	77	0.00064	102	0.00018
6	0.00011	30	0.03923	54	0.00390	78	0.00060	103	0.00017
7	0.00028	31	0.03766	55	0.00352	79	0.00057	104–105	0.00016
8	0.00061	32	0.03582	56	0.00319	80	0.00054	106	0.00015
9	0.00116	33	0.03377	57	0.00289	81	0.00051	107–108	0.00014
10	0.00201	34	0.03159	58	0.00263	82	0.00048	109–110	0.00013
11	0.00323	35	0.02933	59	0.00240	83	0.00045	111–112	0.00012
12	0.00486	36	0.02705	60	0.00219	84	0.00043	113–114	0.00011
13	0.00694	37	0.02480	61	0.00201	85	0.00041	115–117	0.00010
14	0.00944	38	0.02260	62	0.00185	86	0.00038	118–120	0.00009
15	0.01234	39	0.02050	63	0.00170	87	0.00036	121–123	0.00008
16	0.01555	40	0.01852	64	0.00157	88	0.00035	124–128	0.00007
17	0.01899	41	0.01667	65	0.00145	89	0.00033	129–132	0.00006
18	0.02255	42	0.01495	66	0.00134	90	0.00031	133–139	0.00005
19	0.02608	43	0.01338	67	0.00125	91	0.00030	140–147	0.00004
20	0.02947	44	0.01195	68	0.00116	92	0.00028	148–158	0.00003
21	0.03261	45	0.01066	69	0.00108	93	0.00027	159–178	0.00002
22	0.03537	46	0.00950	70	0.00101	94	0.00026	179–256	0.00001
23	0.03769	47	0.00847	71	0.00094	95	0.00025	≥256	0.00000
24	0.03950	48	0.00755	72	0.00088	96	0.00023		

* The F_{T-X} cohorts do not exist for glanders because their populations are always zero

Figure 5-5: Human Response and Casualty Estimation for Glanders

5.2.4. Melioidosis

1. Figure 5-6 summarizes the human response and casualty estimation processes for melioidosis, Table 5-30 summarizes the Injury Profile, and Table 5-31 summarizes the other melioidosis submodels. No prophylaxis is modeled for melioidosis.

2. Cohorts and special considerations.

   a. If $Flag_{MT}$ = No, the population of the E cohort moves into F_U and S_U.

   b. If $Flag_{MT}$ = Yes and the casualty criterion is WIA(1^+) or WIA(2^+), the population of the E cohort moves into F_{T-1} and S_{T-1}.

   c. If $Flag_{MT}$ = Yes and the casualty criterion is WIA(3^+), the population of the E cohort moves into F_{T-2} and S_{T-2}.

3. Assumptions and limitations.

   a. Assumptions.

      1) The population does not have melioidosis risk factors.

      2) When $Flag_{MT}$ = Yes, WIAs begin receiving treatment on the first day they are declared WIA.

   b. Limitation. The methodology only accounts for acute onset melioidosis with pulmonary presentation.

4. Table 5-32 through Table 5-36 are the PDTs for melioidosis. The values from a given table are to be used in Equation 5-5 or 5-6 with the cohort(s) listed in the table header.

Table 5-30: Melioidosis Injury Profile

Stage	Injury Severity Level
Untreated (F_U and S_U)	
1	2
2	4
Treated (F_{T-1}, F_{T-2}, S_{T-1}, and S_{T-2})	
1	2
2	3

Table 5-31: Melioidosis Submodel Summary

Type	Parameter Values (basis of derived values)
Infectivity ($p_E(X^{eff}_{melioidosis,n})$)	
Lognormal Distribution	$\mu = 2.708$; $\sigma = 0.658$ (ID_{50} = 15 CFU; probit slope = 3.50 probits/log(dose))
Lethality (p_L(melioidosis))	
Untreated	
CFR	53%
Treated	
CFR	3%
Incubation Period*	
Lognormal Distribution	$\mu = 1.118$; $\sigma = 0.949$ (mean = 4.8 days; standard deviation = 5.8 days)
Duration of Illness*	
Stage 1: All, Untreated (F_U and S_U) Stage 1: Non-Survivors, Treatment In Stage 1 (F_{T-1}) Stage 1: All, Treatment Initiated in Stage 2 (F_{T-1} and S_{T-1})	
PERT Distribution	$\mu = 3.8$; $\alpha = 1.8$; $\beta = 4.1$ (min = 1 days; max = 10 days; median = 3 days)
Stage 2: Non-Survivors, Untreated (F_U) Stage 2: Non-Survivors, Treated (F_{T-1} and F_{T-2})	
PERT Distribution	$\mu = 4.7$; $\alpha = 1.8$; $\beta = 4.3$ (min = 0 days; max = 16 days; median = 3 days)
Stage 2: Survivors, Untreated (S_U)	
PERT Distribution	$\mu = 18.3$; $\alpha = 2.3$; $\beta = 3.7$ (min = 1 days; max = 47 days; median = 15.5 days)
Total Duration: Survivors, Treatment Initiated in Stage 1 (S_{T-1}) Stage 2: Survivors, Treatment Initiated in Stage 2 (S_{T-2})	
Constant	14 days

* Presented for information only. These two submodels have already been convolved to generate the PDTs; the user should use the PDTs to estimate when changes in casualty category occur.

Table 5-32: Daily Fraction of Individuals Ill with Melioidosis (E) Who Become WIA, for Casualty Criterion WIA(1^+) or WIA(2^+); Daily Fraction of Stage 1 Treated Melioidosis Survivors (S_{T-1}) Who Become CONV

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.1192	14	0.0092	27	0.0012	40	0.0003	53	0.0001
2	0.2077	15	0.0076	28	0.0011	41	0.0003	54	0.0001
3	0.1647	16	0.0063	29	0.0009	42	0.0002	55	0.0001
4	0.1195	17	0.0053	30	0.0008	43	0.0002	56	0.0001
5	0.0865	18	0.0044	31	0.0007	44	0.0002	57	0.0001
6	0.0635	19	0.0038	32	0.0007	45	0.0002	58	0.0001
7	0.0474	20	0.0032	33	0.0006	46	0.0002	59	0.0001
8	0.0360	21	0.0028	34	0.0005	47	0.0001	60	0.0001
9	0.0278	22	0.0024	35	0.0005	48	0.0001	61	0.0001
10	0.0218	23	0.0021	36	0.0004	49	0.0001	62	0.0001
11	0.0173	24	0.0018	37	0.0004	50	0.0001	≥63	0.0000
12	0.0138	25	0.0016	38	0.0003	51	0.0001		
13	0.0112	26	0.0014	39	0.0003	52	0.0001		

Table 5-33: Daily Fraction of Individuals Ill with Melioidosis (E) Who Become WIA, for Casualty Criterion WIA(3^+); Daily Fraction of Stage 2 Treated Melioidosis Survivors (S_{T-2}) Who Become CONV

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0000	15	0.0181	29	0.0016	43	0.0003	57	0.0001
2	0.0026	16	0.0145	30	0.0014	44	0.0003	58	0.0001
3	0.0293	17	0.0116	31	0.0012	45	0.0003	59	0.0001
4	0.0746	18	0.0095	32	0.0011	46	0.0002	60	0.0001
5	0.1120	19	0.0078	33	0.0009	47	0.0002	61	0.0001
6	0.1296	20	0.0065	34	0.0008	48	0.0002	62	0.0001
7	0.1276	21	0.0054	35	0.0007	49	0.0002	63	0.0001
8	0.1121	22	0.0045	36	0.0007	50	0.0002	64	0.0001
9	0.0905	23	0.0038	37	0.0006	51	0.0001	65	0.0001
10	0.0691	24	0.0033	38	0.0005	52	0.0001	66	0.0001
11	0.0517	25	0.0028	39	0.0005	53	0.0001	67	0.0001
12	0.0390	26	0.0024	40	0.0004	54	0.0001	68	0.0001
13	0.0298	27	0.0021	41	0.0004	55	0.0001	69	0.0001
14	0.0231	28	0.0018	42	0.0003	56	0.0001	≥70	0.0000

Table 5-34: Daily Fraction of Untreated or Treated Melioidosis Non-Survivors (F_U, F_{T-1}, or F_{T-2}) Who DOW

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0000	16	0.0544	31	0.0026	46	0.0004	61	0.0001
2	0.0000	17	0.0448	32	0.0022	47	0.0003	62	0.0001
3	0.0007	18	0.0361	33	0.0019	48	0.0003	63	0.0001
4	0.0044	19	0.0287	34	0.0016	49	0.0003	64	0.0001
5	0.0135	20	0.0226	35	0.0014	50	0.0003	65	0.0001
6	0.0278	21	0.0178	36	0.0013	51	0.0002	66	0.0001
7	0.0449	22	0.0141	37	0.0011	52	0.0002	67	0.0001
8	0.0619	23	0.0112	38	0.0010	53	0.0002	68	0.0001
9	0.0759	24	0.0090	39	0.0009	54	0.0002	69	0.0001
10	0.0850	25	0.0074	40	0.0008	55	0.0002	70	0.0001
11	0.0886	26	0.0061	41	0.0007	56	0.0001	71	0.0001
12	0.0873	27	0.0050	42	0.0006	57	0.0001	72	0.0001
13	0.0819	28	0.0042	43	0.0005	58	0.0001	73	0.0001
14	0.0739	29	0.0035	44	0.0005	59	0.0001	≥74	0.0000
15	0.0644	30	0.0030	45	0.0004	60	0.0001		

Table 5-35: Daily Fraction of Stage 1 Treated Melioidosis Survivors (S_{T-1}) Who Become RTD

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
15	0.1192	28	0.0092	41	0.0012	54	0.0003	67	0.0001
16	0.2077	29	0.0076	42	0.0011	55	0.0003	68	0.0001
17	0.1647	30	0.0063	43	0.0009	56	0.0002	69	0.0001
18	0.1195	31	0.0053	44	0.0008	57	0.0002	70	0.0001
19	0.0865	32	0.0044	45	0.0007	58	0.0002	71	0.0001
20	0.0635	33	0.0038	46	0.0007	59	0.0002	72	0.0001
21	0.0474	34	0.0032	47	0.0006	60	0.0002	73	0.0001
22	0.0360	35	0.0028	48	0.0005	61	0.0001	74	0.0001

23	0.0278	36	0.0024	49	0.0005	62	0.0001	75	0.0001
24	0.0218	37	0.0021	50	0.0004	63	0.0001	76	0.0001
25	0.0173	38	0.0018	51	0.0004	64	0.0001	≥77	0.0000
26	0.0138	39	0.0016	52	0.0003	65	0.0001		
27	0.0112	40	0.0014	53	0.0003	66	0.0001		

Table 5-36: Daily Fraction of Stage 2 Treated Melioidosis Survivors (S_{T-2}) Who Become RTD

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
15	0.0000	29	0.0181	43	0.0016	57	0.0003	71	0.0001
16	0.0026	30	0.0145	44	0.0014	58	0.0003	72	0.0001
17	0.0293	31	0.0116	45	0.0012	59	0.0003	73	0.0001
18	0.0746	32	0.0095	46	0.0011	60	0.0002	74	0.0001
19	0.1120	33	0.0078	47	0.0009	61	0.0002	75	0.0001
20	0.1296	34	0.0065	48	0.0008	62	0.0002	76	0.0001
21	0.1276	35	0.0054	49	0.0007	63	0.0002	77	0.0001
22	0.1121	36	0.0045	50	0.0007	64	0.0002	78	0.0001
23	0.0905	37	0.0038	51	0.0006	65	0.0001	79	0.0001
24	0.0691	38	0.0033	52	0.0005	66	0.0001	80	0.0001
25	0.0517	39	0.0028	53	0.0005	67	0.0001	81	0.0001
26	0.0390	40	0.0024	54	0.0004	68	0.0001	82	0.0001
27	0.0298	41	0.0021	55	0.0004	69	0.0001	83	0.0001
28	0.0231	42	0.0018	56	0.0003	70	0.0001	≥84	0.0000

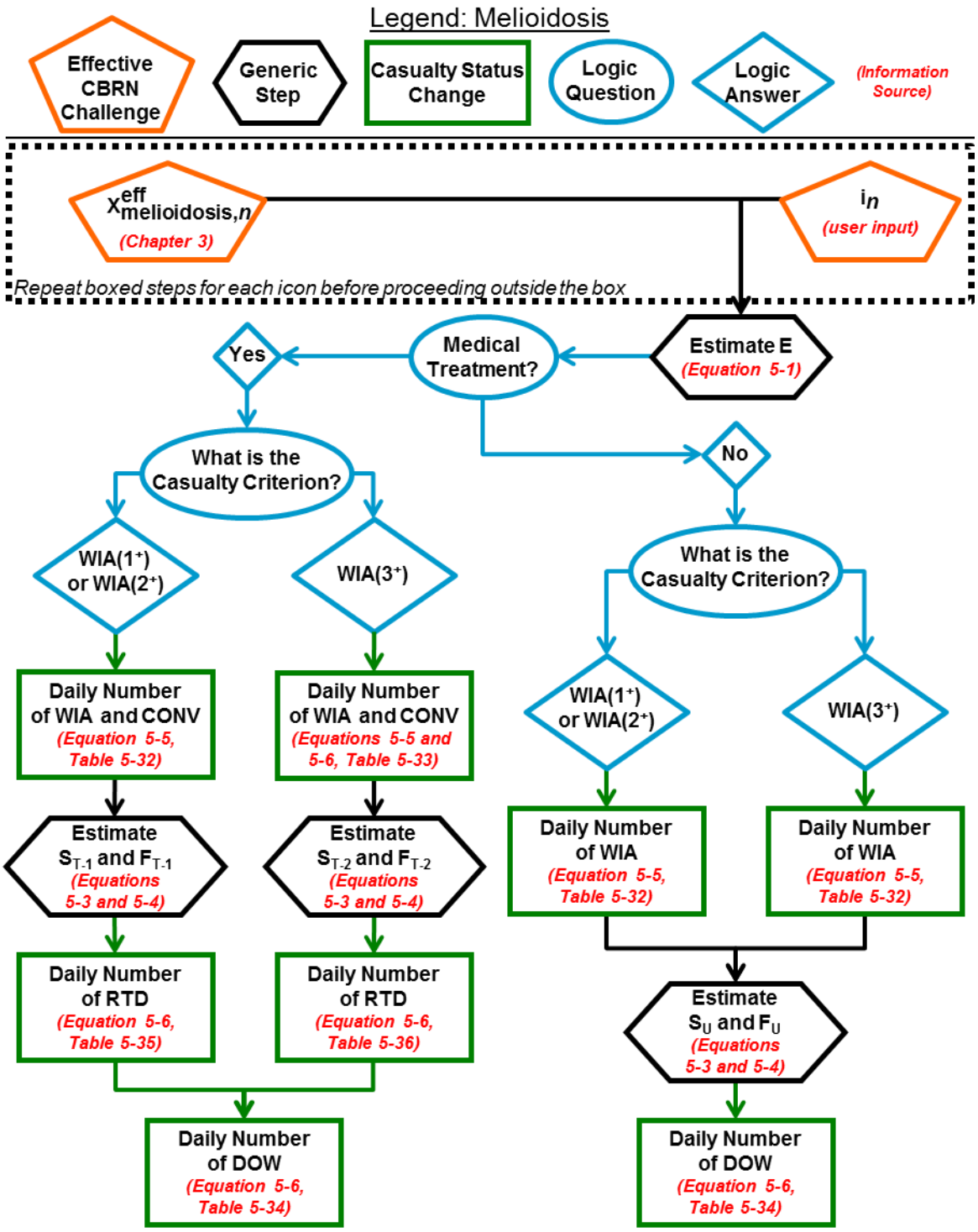


Figure 5-6: Human Response and Casualty Estimation for Melioidosis

5.2.5. Plague (non-contagious)

1. Figure 5-7 summarizes the human response and casualty estimation processes for plague, Table 5-37 summarizes the Injury Profile, Table 5-39 summarizes the other plague submodels, and Table 5-38 summarizes the available plague prophylaxis options.

2. Cohorts and special considerations.

   a. If $Flag_{MT}$ = No, the population of the E cohort moves into F_U, and the S_U cohort does not exist because its population is always zero.

   b. If $Flag_{MT}$ = Yes and the casualty criterion is WIA(1^+) or WIA(2^+), the population of the E cohort moves into S_{T-1}, and the F_{T-1} cohort does not exist because its population is always zero.

   c. If $Flag_{MT}$ = Yes and the casualty criterion is WIA(3^+), the population of the E cohort moves into F_{T-2}, and the S_{T-2} cohort does not exist because its population is always zero.

3. Assumptions.

   a. The disease resulting from exposure to *Y. pestis* is pneumonic plague.

   b. Untreated pneumonic plague is 100% lethal.

   c. When $Flag_{MT}$ = Yes, WIAs begin receiving treatment on the first day they are declared WIA.

4. Table 5-40 through Table 5-43 are the PDTs for plague. The values from a given table are to be used in Equation 5-5 or 5-6 with the cohort(s) listed in the table header.

Table 5-37: Plague Injury Profile

Stage	Injury Severity Level
Untreated (F_U) and Treated (F_{T-2}) Non-Survivors	
1	2
2	4
Treated Survivors (S_{T-1})	
1	2
2	2

Table 5-38: Plague Prophylaxis Summary

Type of Prophylaxis	Efficacy (ρ_n)
Pre-exposure antibiotics or vaccination[71]	0.95
Post-exposure antibiotics	0.95

Table 5-39: Plague Submodel Summary

Type	Parameter Values (basis of derived values)
Infectivity ($p_F(X^{eff}_{plague,n})$)	
Lognormal Distribution	$\mu = 4.190$; $\sigma = 2.303$ (ID_{50} = 66 CFU; probit slope = 1 probit/log(dose))
Lethality (p_f(plague))	
Untreated	
CFR	100%
Treatment Initiated in Stage 1	
CFR	0%
Incubation Period*	
Lognormal Distribution	$\mu = 1.378$; $\sigma = 0.402$ (mean = 4.3 days; standard deviation = 1.8 days)
Duration of Illness*	
Stage 1: All (F_U, S_{T-1}, and F_{T-2})	
Constant	1 day
Stage 2: Non-Survivors, Untreated (F_U) Stage 2: Non-Survivors, Treatment Initiated in Stage 2 (F_{T-2})	
Lognormal Distribution	$\mu = 0.158$; $\sigma = 0.703$ (mean = 1.5 days; standard deviation = 1.2 days)
Stage 2: Survivors, Treatment Initiated in Stage 1 (S_{T-1})	
Constant	10 days

* Presented for information only. These two submodels have already been convolved to generate the PDTs; the user should use the PDTs to estimate when changes in casualty category occur.

Table 5-40: Daily Fraction of Individuals Ill with Plague (E) Who Become WIA, for Casualty Criterion WIA(1^+) or WIA(2^+)

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0003	6	0.1307	11	0.0051	16	0.0002	≥21	0.0000
2	0.0439	7	0.0728	12	0.0026	17	0.0001		
3	0.1993	8	0.0383	13	0.0014	18	0.0001		
4	0.2648	9	0.0197	14	0.0007	19	0.0001		
5	0.2094	10	0.0100	15	0.0004	20	0.0001		

[71] Note that not all NATO nations have a plague vaccine.

Table 5-41: Daily Fraction of Individuals Ill with Plague (E) Who Become WIA, for Casualty Criterion WIA(3^+); Daily Fraction of Stage 1 Treated Plague Survivors (S_{T-1}) Who Become CONV

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0000	6	0.2094	11	0.0100	16	0.0004	21	0.0001
2	0.0003	7	0.1307	12	0.0051	17	0.0002	≥22	0.0000
3	0.0439	8	0.0728	13	0.0026	18	0.0001		
4	0.1993	9	0.0383	14	0.0014	19	0.0001		
5	0.2648	10	0.0197	15	0.0007	20	0.0001		

Table 5-42: Daily Fraction of Untreated or Treated Plague Non-Survivors (F_U or F_{T-2}) Who DOW

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0000	6	0.2133	11	0.0349	16	0.0020	21	0.0001
2	0.0000	7	0.2017	12	0.0198	17	0.0011	22	0.0001
3	0.0024	8	0.1511	13	0.0111	18	0.0007	23	0.0001
4	0.0446	9	0.0991	14	0.0062	19	0.0004	≥24	0.0000
5	0.1474	10	0.0602	15	0.0035	20	0.0002		

Table 5-43: Daily Fraction of Stage 1 Treated Plague Survivors (S_{T-1}) Who Become RTD

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
11	0.0000	16	0.2094	21	0.0100	26	0.0004	31	0.0001
12	0.0003	17	0.1307	22	0.0051	27	0.0002	≥32	0.0000
13	0.0439	18	0.0728	23	0.0026	28	0.0001		
14	0.1993	19	0.0383	24	0.0014	29	0.0001		
15	0.2648	20	0.0197	25	0.0007	30	0.0001		

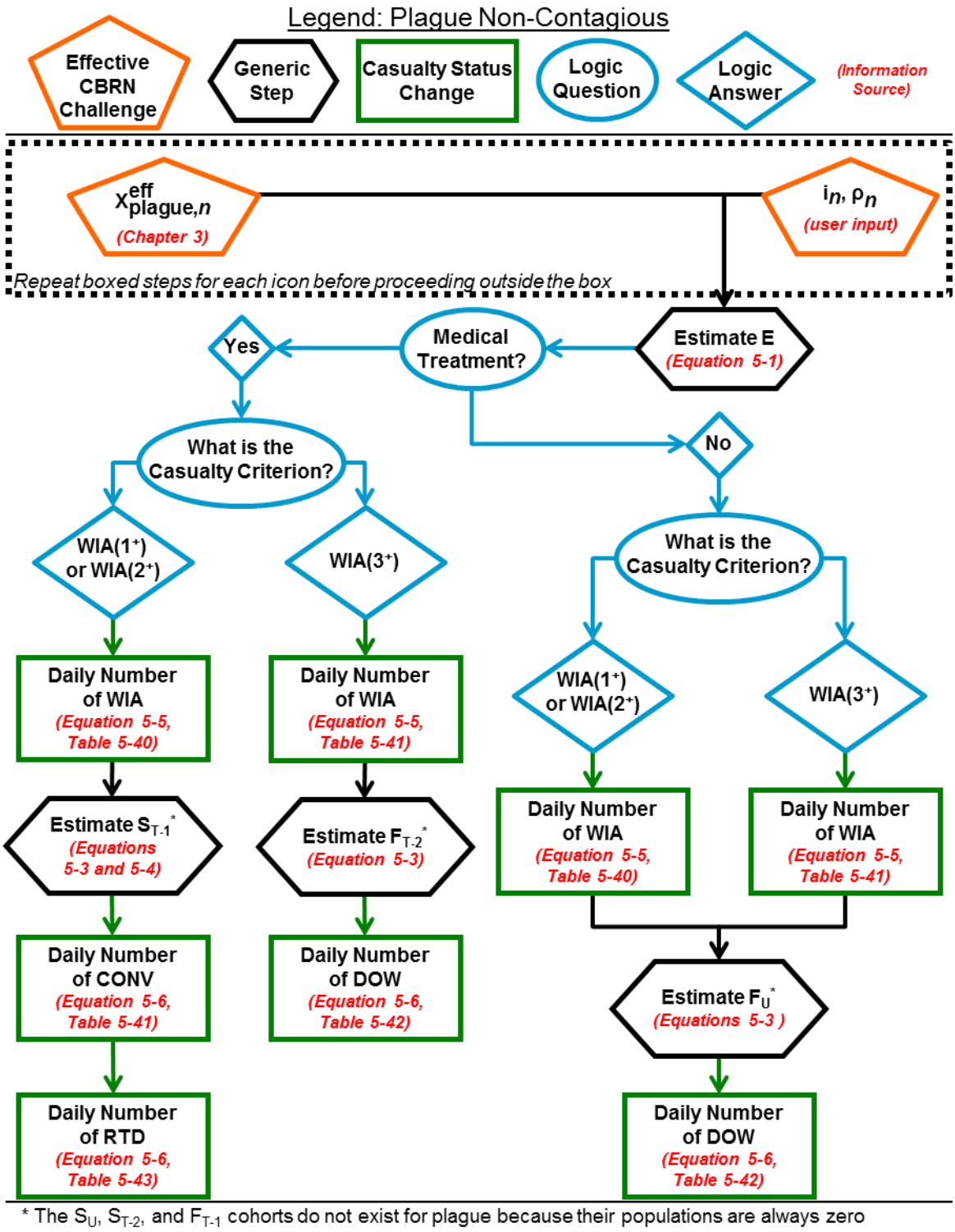


Figure 5-7: Human Response and Casualty Estimation for Plague (non-contagious)

5.2.6. Plague (contagious)

1. As stated in section 5.1.4.1 and Table 5-2, the user is advised to use this model only if the casualty criterion is WIA(3^+).

2. The contagious plague model uses the same Injury Profile (Table 5-37), prophylaxis options (Table 5-38), infectivity model (Table 5-39), and untreated lethality model (Table 5-39) as the non-contagious model. However, the parameter values representing the incubation period and duration of illness models are different because of limitations in the SEIRP model. The SEIRP model also requires values for α and β(d). The values of parameters that are different in or unique to the SEIRP model are presented in Table 5-44.

3. Assumptions.

   a. The disease resulting from exposure to *Y. pestis* is pneumonic plague.

   b. Untreated pneumonic plague is 100% lethal.

4. When $Flag_{MT}$ = Yes, there is no difference in the operation of the model. The only change in output is that upon entering the $R_m(d)$ cohort, individuals become RTD instead of remaining WIA.

Table 5-44: SEIRP Model Parameter Values for Plague

Parameter	Value
ρ_S	0.95
ρ_E	0.95
μ_{E1}	1 day
μ_{E2}	3.3 days
μ_1	1 day
μ_2	1.5 days
α	0
β(d)	See Table 5-45
$\nu_{on}(d)$	1 for d = 0 days; 0 for d ≠ 0 days
$\nu_{off}(d)$	1 for d = 7 days; 0 for d ≠ 7 days

Table 5-45: β(d) Values for Plague[72]

Day	β(d)	Day	β(d)	Day	β(d)	Day	β(d)	Day	β(d)
1	0	8	1.27051	15	1.751387	22	0.213678	29	0.34088
2	1.399368	9	2.046092	16	1.53121	23	0.129681	30	0.348683
3	2.114316	10	2.311747	17	1.120241	24	0.073931	31	0.239461
4	3.924383	11	2.272985	18	0.629848	25	0.190478	32	0.131417
5	4.323217	12	1.955047	19	0.375698	26	0.468109	33	0.016763
6	3.461722	13	1.639616	20	0.269083	27	0.554607	≥34	0
7	1.027207	14	1.723586	21	0.250477	28	0.44357		

5.2.7. Q Fever

1. Figure 5-8 summarizes the human response and casualty estimation processes for Q fever, Table 5-47 summarizes the Injury Profile, Table 5-49 summarizes the other Q fever submodels, and Table 5-48 summarizes the available Q fever prophylaxis options.

2. Cohorts and special considerations.

   a. The Q fever incubation period model is dose-dependent; Table 5-46 summarizes the dose ranges. The E and S cohorts are split into sub-cohorts labeled as E_{DR} and S_{DR}, where DR is the dose range label given in Table 5-46. The population of each E, F, and S sub-cohort is calculated separately for each dose range by applying Equations 5-1, 5-3, and 5-4 to the appropriate range of doses.

Table 5-46: Q Fever Dose Ranges

Dose Range Label	Dose Range (organisms)		Dose Range Label	Dose Range (organisms)	
	>	≤		>	≤
A	0	2	K	127756	434808
B	2	7	L	434808	1479833
C	7	24	M	1479833	5036486
D	24	82	N	5036486	17141252
E	82	279	O	17141252	58338793
F	279	952	P	58338793	198551119
G	952	3240	Q	198551119	675751835
H	3240	11029	R	675751835	2299863853
I	11029	37537	S	2299863853	7827390868
J	37537	127756	T	7827390868	

   b. Q fever does not cause any fatalities, so there is no F cohort, and the entire populations of the E_{DR} cohorts move into $S_{DR,U}$ or $S_{DR,T}$, depending on the value of $Flag_{MT}$.

[72] Derived from an outbreak in Mukden, China in 1946.

3. Assumptions.

   a. Q fever does not cause any fatalities.

   b. When $Flag_{MT}$ = Yes, WIAs begin receiving treatment on the first day they are declared WIA.

4. Table 5-50 through Table 5-51 are the PDTs for Q fever. The values from a given table are to be used in Equation 5-5 or 5-6 with the cohort listed in the table header.

Table 5-47: Q Fever Injury Profile

Stage	Injury Severity Level
1	2

Table 5-48: Q Fever Prophylaxis Summary

Type of Prophylaxis	Efficacy (ρ_n)
Pre-exposure vaccination	1.00

Table 5-49: Q Fever Submodel Summary

Type	Parameter Values (basis of derived values)
Infectivity ($p_E(X^{eff}_{Q\ fever,n})$)	
Lognormal Distribution	μ = 3.401; σ = 2.944 (ID_{50} = 30 organisms; probit slope = 0.782 probits/log(dose))
Lethality (p_f(Q fever))	
CFR	0%
Incubation Period*	
Log-linear function	m = -1.88 days; b = 19.6 days
Duration of Illness*	
Stage 1: Survivors, Untreated ($S_{DR,U}$)	
Lognormal Distribution	μ = 2.361; σ = 0.514 (mean = 12.1 days; standard deviation = 6.66 days)
Stage 1: Survivors, Treated ($S_{DR,T}$)	
Constant	5 days

* Presented for information only. These two submodels have already been convolved to generate the PDTs; the user should use the PDTs to estimate when changes in casualty category occur.

Table 5-50: Dose-Dependent Day on Which Individuals Ill with Q Fever (E_{DR}) Become WIA, for Casualty Criterion WIA(1^+) or WIA(2^+)

Day	Dose Range	Day	Dose Range	Day	Dose Range	Day	Dose Range
20	A	15	F	10	K	5	P
19	B	14	G	9	L	4	Q
18	C	13	H	8	M	3	R
17	D	12	I	7	N	2	S
16	E	11	J	6	O	1	T

Table 5-51: Dose-Dependent Day on Which Treated Q Fever Survivors ($S_{DR,T}$) Become RTD

Day	Dose Range	Day	Dose Range	Day	Dose Range	Day	Dose Range
25	A	20	F	15	K	10	P
24	B	19	G	14	L	9	Q
23	C	18	H	13	M	8	R
22	D	17	I	12	N	7	S
21	E	16	J	11	O	6	T

Figure 5-8: Human Response and Casualty Estimation for Q Fever

5.2.8. Tularemia

1. Figure 5-9 summarizes the human response and casualty estimation processes for tularemia, Table 5-53 summarizes the Injury Profile, and Table 5-54 summarizes the other tularemia submodels. No prophylaxis is modeled for tularemia.

2. Cohorts and special considerations.

   a. The tularemia incubation period model is dose-dependent; Table 5-52 summarizes the dose ranges. The E, F, and S cohorts are split into sub-cohorts labeled as E_{DR}, F_{DR}, and S_{DR}, where DR is the dose range label given in Table 5-52. The population of each E, F, and S sub-cohort is calculated separately for each dose range by applying Equations 5-1, 5-3, and 5-4 to the appropriate range of doses.

Table 5-52: Tularemia Dose Ranges

Dose Range Label	Dose Range (organisms)	
	>	≤
A	0	4
B	4	75
C	75	1241
D	1241	20502
E	20502	421696
F	421696	

   b. If $Flag_{MT}$ = No, the populations of the E_{DR} cohorts move into $F_{DR,U}$ and $S_{DR,U}$.

   c. If $Flag_{MT}$ = Yes, the population of the E_{DR} cohort moves into $S_{DR,T}$, and the $F_{DR,T}$ cohort does not exist because its population is always zero.

3. Assumptions.

   a. Inhalation of *F. tularensis* results in typhoidal tularemia with pneumonia.

   b. When $Flag_{MT}$ = Yes, WIAs begin receiving treatment on the first day they are declared WIA.

4. Table 5-55 through Table 5-57 are the PDTs for tularemia. The values from a given table are to be used in Equation 5-5 or 5-6 with the cohort listed in the table header.

Table 5-53: Tularemia Injury Profile

Stage	Injury Severity Level
Untreated Non-Survivors ($F_{DR,U}$)	
1	3
2	4
Untreated Survivors ($S_{DR,U}$)	
1	3
2	3
3	2
Treated Survivors ($S_{DR,T}$)	
1	3
2	2

Table 5-54: Tularemia Submodel Summary

Type	Parameter Values (basis of derived values)
Infectivity ($p_F(X^{eff}_{tularemia,n})$)	
Lognormal Distribution	$\mu = 2.303$; $\sigma = 1.212$ (ID_{50} = 10 organisms; probit slope = 1.90 probits/log(dose))
Lethality (p_f(tularemia))	
Untreated	
CFR	75%
Treated	
CFR	0%
Incubation Period*	
For $X^{eff}_{tularemia,n}$ < 106,604 organisms	
Log-linear Function	m = -0.8207 days; b = 6.538 days
For 106,604 organisms < $X^{eff}_{tularemia,n}$ < 9,019,577 organisms	
Log-quadratic Function	a = 0.1763 days; b = -2.589 days, c = 10.96 days
For $X^{eff}_{tularemia,n}$ ≥ 9,019,577 organisms	
Constant	1.5 days
Duration of Illness*	
Stage 1: Non-survivor, Untreated ($F_{DR,U}$)	
Constant	9 days
Stage 2: Non-survivor, Untreated ($F_{DR,U}$)	
Constant	6 days
Stage 1: Survivor, Untreated ($S_{DR,U}$)	
Constant	12 days
Stage 2: Survivor, Untreated ($S_{DR,U}$)	
Constant	28 days
Stage 3: Survivor, Untreated ($S_{DR,U}$)	
Constant	84 days
Stage 1: Survivor, Treated ($S_{DR,T}$)	
Constant	4 days
Stage 2: Survivor, Treated ($S_{DR,T}$)	
Constant	6 days

* Presented for information only. These two submodels have already been convolved to generate the PDTs; the user should use the PDTs to estimate when changes in casualty category occur.

Table 5-55: Dose-Dependent Day on Which Individuals Ill with Tularemia (E_{DR}) Become WIA, for Any Casualty Criterion

Day	Dose Range	Day	Dose Range	Day	Dose Range	Day	Dose Range
≥8	(none)	6	B	4	D	2	F
7	A	5	C	3	E	1	(none)

Table 5-56: Dose-Dependent Day on Which Untreated Tularemia Non-Survivors ($F_{DR,U}$) DOW

Day	Dose Range	Day	Dose Range	Day	Dose Range	Day	Dose Range
≥23	(none)	21	B	19	D	17	F
22	A	20	C	18	E	≤16	(none)

Table 5-57: Dose-Dependent Day on Which Treated Tularemia Survivors ($S_{DR,T}$) Become RTD

Day	Dose Range	Day	Dose Range	Day	Dose Range	Day	Dose Range
≥18	(none)	16	B	14	D	12	F
17	A	15	C	13	E	≤11	(none)

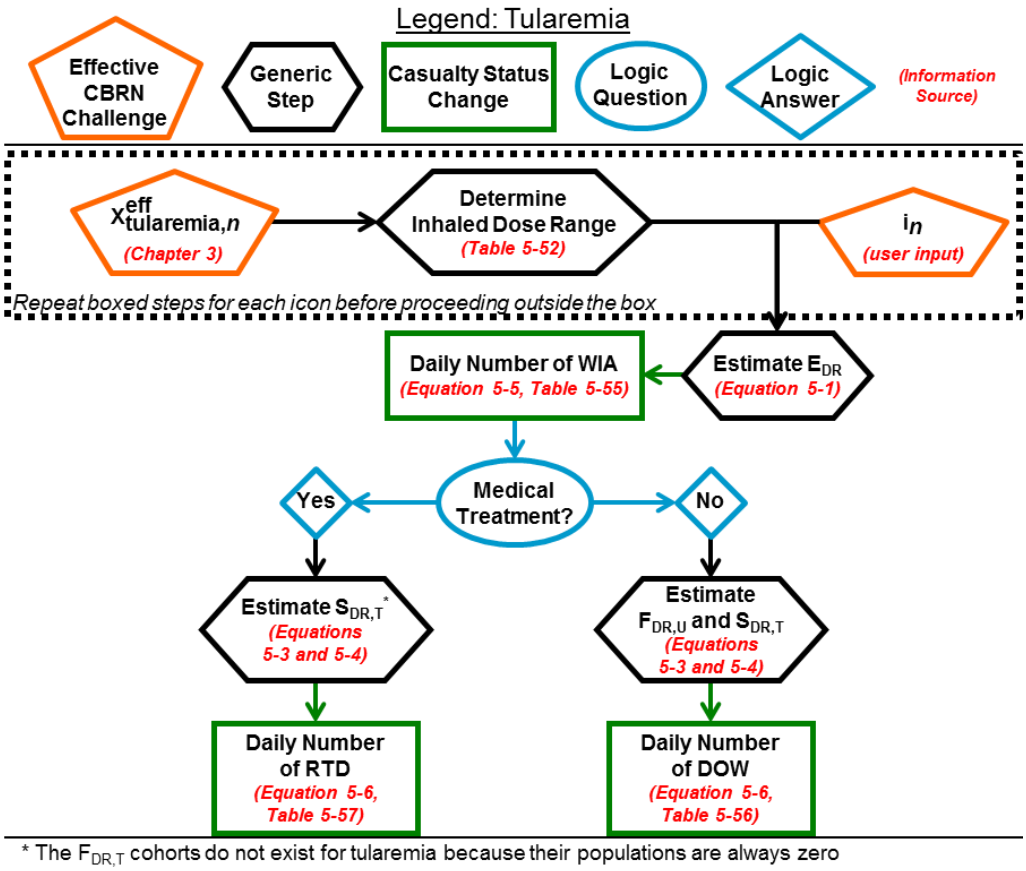


Figure 5-9: Human Response and Casualty Estimation for Tularemia

5.2.9. Smallpox (non-contagious)

1. Figure 5-10 summarizes the human response and casualty estimation processes for smallpox, Table 5-58 summarizes the Injury Profile, Table 5-60 summarizes the other plague submodels, and Table 5-59 summarizes the available smallpox prophylaxis options.

2. Cohorts and special considerations.

   a. Medical treatment has no effect on the submodel parameter values, so the value of $Flag_{MT}$ only determines whether RTD is estimated.

   b. Because the lethality model is different for the unvaccinated population and the population that was vaccinated but did not gain immunity, the population must be split into different cohorts based on whether they were vaccinated. To accomplish this, Equation 5-1 must be used twice.

      1) If an icon was not vaccinated, it is in the E_U cohort. The population of the E_U cohort moves into F_U and S_U.

      2) If an icon was vaccinated (either pre-exposure or post-exposure, pre-symptom onset), it is in the E_V cohort. The population of the E_V cohort moves into F_V and S_V.

3. Assumptions.

   a. Inhalation of *V. major* results in "ordinary-type" (discrete) smallpox.

   b. The case fatality rates for populations vaccinated before and after exposure (pre-symptom onset) are the same.

4. Table 5-61 through Table 5-64 are the PDTs for smallpox. The values from a given table are to be used in Equation 5-5 or 5-6 with the cohort(s) listed in the table header.

Table 5-58: Smallpox Injury Profile

Stage	Injury Severity Level
Non-survivors (F_U and F_V)	
1	2
2	4
Survivors (S_U and S_V)	
1	2
2	3
3	1

Table 5-59: Smallpox Prophylaxis Summary

Type of Prophylaxis	Efficacy (ρ_n)
Pre-exposure vaccination	0.95
Post-exposure vaccination	0.85

Table 5-60: Smallpox Submodel Summary

Type	Parameter Values (basis of derived values)
Infectivity ($p_E(X^{eff}_{smallpox,n})$)	
Threshold	10 PFU
Lethality (p_f(smallpox))	
Unvaccinated	
CFR	30%
Vaccinated	
CFR	3%
Incubation Period*	
Lognormal Distribution	$\mu = 2.439$; $\sigma = 0.154$ (mean = 11.6 days; standard deviation = 1.8 days)
Duration of Illness*	
Under development	

* Presented for information only. These two submodels have already been convolved to generate the PDTs; the user should use the PDTs to estimate when changes in casualty category occur.

Table 5-61: Daily Fraction of Individuals Ill with Smallpox (E_U and E_V) Who Become WIA, for Casualty Criterion WIA(1+) or WIA(2+)

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0000	6	0.0000	11	0.2066	16	0.0253	21	0.0001
2	0.0000	7	0.0007	12	0.2221	17	0.0100	≥22	0.0000
3	0.0000	8	0.0092	13	0.1760	18	0.0036		
4	0.0000	9	0.0486	14	0.1099	19	0.0012		
5	0.0000	10	0.1296	15	0.0568	20	0.0004		

Table 5-62: Daily Fraction of Individuals Ill with Smallpox (E_U and E_V) Who Become WIA, for Casualty Criterion WIA(3+)

Pending development of duration of illness model

Table 5-63: Daily Fraction of Smallpox Non-Survivors (F_U and F_V) Who DOW

Pending development of duration of illness model

Table 5-64: Daily Fraction of Smallpox Survivors (S_U and S_V) Who Become RTD

Pending development of duration of illness model

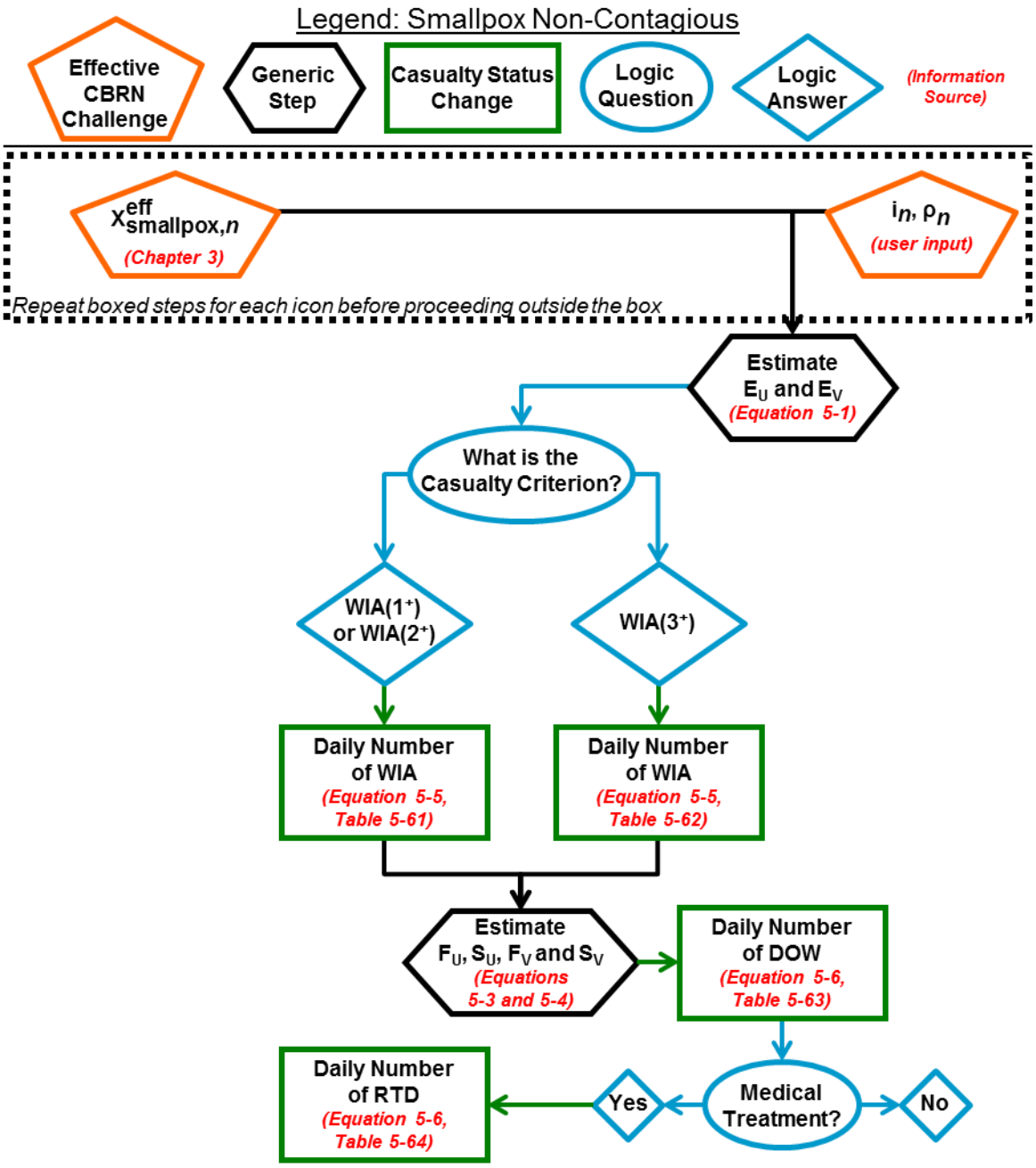


Figure 5-10: Human Response and Casualty Estimation Flowchart for Smallpox

5.2.10. Smallpox (contagious)

1. As stated in section 5.1.4.1 and Table 5-2, the user is advised to use this model only if the casualty criterion is WIA(3^+).

2. The contagious smallpox model uses the same Injury Profile (Table 5-58),

prophylaxis options (Table 5-59), infectivity model (Table 5-60), and lethality models (Table 5-60) as the non-contagious model. However, the parameter values representing the incubation period and duration of illness models are different because of limitations in the SEIRP model. The SEIRP model also requires values for α and β(d). The values of parameters that are different in or unique to the contagious smallpox model are presented in Table 5-65.

3. Assumptions.

a. Inhalation of *V. major* results in "ordinary-type" (discrete) smallpox.

b. The case fatality rates for populations vaccinated before and after exposure (pre-symptom onset) are the same.

c. Although smallpox survivors go through three stages of illness, the SEIRP model is a two-stage model. Thus, survivors in Stage 3 are modeled to move to the R_m(d) cohort, under the assumption that they are not contagious.

4. When $Flag_{MT}$ = Yes, there is no difference in the operation of the model. The only change in output is that upon entering the R_m(d) cohort, individuals become RTD instead of remaining WIA. Thus, survivors are estimated to RTD earlier than they should because the equation cannot account for a duration of residence in the R_m(d) cohort.

Table 5-65: SEIRP Model Parameter Values for Smallpox

Parameter	Values
ρ_S	0.95
ρ_E	0.85
μ_{E1}	7 days
μ_{E2}	4.6 days
μ_1	3 days
μ_2	12.6 days
α	0
β(d)	See Table 5-66
ν_{on}(d)	1 for d = 1 day; 0 for d ≠ 1 day
ν_{off}(d)	0 for d = all days

Table 5-66: β(d) Values for Smallpox[73]

Day	β(d)	Day	β(d)	Day	β(d)	Day	β(d)	Day	β(d)
1	0	13	1.542974	25	0.247143	37	1.446131	49	0.025919
2	0	14	2.111101	26	0.388846	38	0.863064	50	0.018504
3	0	15	2.591886	27	0.604160	39	0.479383	51	0.014492
4	0	16	2.839314	28	0.924223	40	0.240765	52	0.014431
5	0	17	2.732802	29	1.373969	41	0.128126	53	0.014761
6	0	18	2.297896	30	1.811670	42	0.091291	54	0.014046
7	0	19	1.728424	31	2.348062	43	0.081089	55	0.012443
8	0	20	1.049111	32	2.845923	44	0.077639	56	0.009195
9	0.268622	21	0.521604	33	3.144000	45	0.074428	57	0.005397
10	0.455054	22	0.213071	34	3.101436	46	0.068250	58	0.002317
11	0.752619	23	0.108068	35	2.690281	47	0.055961	59	0.000277
12	1.138454	24	0.158733	36	2.115178	48	0.038779	≥60	0

5.2.11. Ebola Virus Disease (EVD) and Marburg Virus Disease (MVD) (non-contagious)

Model is under development and will be included in Study Draft 3.

5.2.12. Ebola Virus Disease (EVD) and Marburg Virus Disease (MVD) (contagious)

Model is under development and will be included in Study Draft 3.

5.2.13. Eastern Equine Encephalitis (EEE)

1. Figure 5-11 summarizes the human response and casualty estimation processes for EEE, Table 5-67 summarizes the Injury Profile, and Table 5-68 summarizes the other EEE submodels. No prophylaxis is modeled for EEE.

2. Cohorts and special considerations.

   a. Medical treatment has no effect on the submodel parameter values, so the value of $Flag_{MT}$ only determines whether CONV and RTD are estimated.

   b. Half of all EEE survivors are estimated to have permanent neurological impairment. Thus, the S cohort is split into two groups, according to Equation 5-37.

$$S_{CONV} = S_{RTD} = 0.5 \cdot S, \tag{5-37}$$

   where:

[73] Derived from an outbreak in Yugoslavia in 1972.

S_{CONV} is the population of survivors who are estimated to be permanently CONV due to neurological impairment, and

S_{RTD} is the population of survivors who have no neurological impairment and therefore are estimated to become RTD.

3. Assumptions.

a. Inhalation of EEE virus results in encephalitic disease.

b. The virus is a North American strain.

c. For the lethality, Injury Profile, and duration of illness submodels: human response is independent of the route of exposure (inhalation versus vector-borne).

4. Table 5-69 through Table 5-72 are the PDTs for EEE. The values from a given table are to be used in Equation 5-5 or 5-6 with the cohort(s) listed in the table header.

Table 5-67: EEE Injury Profile

Stage	Injury Severity Level
1	2
2	3
3	3

Table 5-68: EEE Submodel Summary

Type	Parameter Values (basis of derived values)
Infectivity ($p_E(X^{eff}_{EEE,n})$)	
Threshold	$3.65 \cdot 10^6$ PFU
Lethality (p_f(EEE))	
CFR	33%
Incubation Period*	
Lognormal Distribution	μ = 1.303; σ = 0.407 (mean = 4.0 days; standard deviation = 1.7 days)
Duration of Illness*	
Stage 1: All (F, S_{CONV}, and S_{RTD})	
Lognormal Distribution	μ = 1.618; σ = 0.494 (mean = 5.7 days; standard deviation = 3.0 days)
Stages 2 and 3 (total): Non-Survivors (F)	
Lognormal Distribution	μ = 2.393; σ = 0.499 (mean = 12.4 days; standard deviation = 6.6 days)
Stages 2 and 3 (total): Survivors (S_{CONV} and S_{RTD})	
Lognormal Distribution	μ = 2.567; σ = 0.492 (mean = 14.7 days; standard deviation = 7.7 days)

* Presented for information only. These two submodels have already been convolved to generate the PDTs; the user should use the PDTs to estimate when changes in casualty category occur.

Table 5-69: Daily Fraction of Individuals Ill with EEE (E) Who Become WIA, for Casualty Criterion WIA(1^+) or WIA(2^+)

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0007	5	0.1931	9	0.0143	13	0.0009	17	0.0001
2	0.0665	6	0.1109	10	0.0070	14	0.0005	≥18	0.0000
3	0.2406	7	0.0579	11	0.0035	15	0.0002		
4	0.2730	8	0.0290	12	0.0017	16	0.0001		

Table 5-70: Daily Fraction of Individuals Ill with EEE (E) Who Become WIA, for Casualty Criterion WIA(3^+)

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0000	9	0.1369	17	0.0155	25	0.0009	33	0.0001
2	0.0000	10	0.1235	18	0.0108	26	0.0007	34	0.0001
3	0.0003	11	0.1024	19	0.0075	27	0.0005	35	0.0001
4	0.0057	12	0.0801	20	0.0053	28	0.0003	36	0.0001
5	0.0282	13	0.0601	21	0.0037	29	0.0002	≥37	0.0000
6	0.0690	14	0.0438	22	0.0026	30	0.0002		
7	0.1103	15	0.0313	23	0.0018	31	0.0001		
8	0.1344	16	0.0221	24	0.0013	32	0.0001		

Table 5-71: Daily Fraction of EEE Non-Survivors (F) Who DOW

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0000	15	0.0457	29	0.0262	43	0.0027	57	0.0003
2	0.0000	16	0.0538	30	0.0226	44	0.0023	58	0.0003
3	0.0000	17	0.0599	31	0.0194	45	0.0020	59	0.0002
4	0.0000	18	0.0637	32	0.0166	46	0.0017	60	0.0002
5	0.0000	19	0.0651	33	0.0142	47	0.0014	61	0.0002
6	0.0000	20	0.0644	34	0.0121	48	0.0012	62	0.0001
7	0.0001	21	0.0620	35	0.0103	49	0.0010	63	0.0001
8	0.0005	22	0.0584	36	0.0087	50	0.0009	64	0.0001
9	0.0018	23	0.0540	37	0.0074	51	0.0008	65	0.0001
10	0.0047	24	0.0492	38	0.0063	52	0.0006	66	0.0001
11	0.0098	25	0.0442	39	0.0053	53	0.0006	67	0.0001
12	0.0172	26	0.0392	40	0.0045	54	0.0005	68	0.0001
13	0.0263	27	0.0345	41	0.0038	55	0.0004	69	0.0001
14	0.0362	28	0.0301	42	0.0032	56	0.0004	≥70	0.0000

Table 5-72: Daily Fraction of EEE Survivors Who Become CONV (S_{CONV}) or RTD (S_{RTD})

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0000	17	0.0457	33	0.0204	49	0.0021	65	0.0002
2	0.0000	18	0.0513	34	0.0179	50	0.0018	66	0.0002
3	0.0000	19	0.0553	35	0.0156	51	0.0016	67	0.0002
4	0.0000	20	0.0576	36	0.0136	52	0.0014	68	0.0002
5	0.0000	21	0.0582	37	0.0118	53	0.0012	69	0.0002
6	0.0000	22	0.0573	38	0.0103	54	0.0010	70	0.0001
7	0.0000	23	0.0553	39	0.0089	55	0.0009	71	0.0001
8	0.0002	24	0.0525	40	0.0077	56	0.0008	72	0.0001
9	0.0007	25	0.0490	41	0.0067	57	0.0007	73	0.0001

10	0.0021	26	0.0452	42	0.0058	58	0.0006	74	0.0001
11	0.0048	27	0.0413	43	0.0050	59	0.0005	75	0.0001
12	0.0092	28	0.0373	44	0.0043	60	0.0005	76	0.0001
13	0.0153	29	0.0334	45	0.0038	61	0.0004	77	0.0001
14	0.0227	30	0.0298	46	0.0033	62	0.0004	78	0.0001
15	0.0308	31	0.0264	47	0.0028	63	0.0003	≥79	0.0000
16	0.0386	32	0.0233	48	0.0024	64	0.0003		

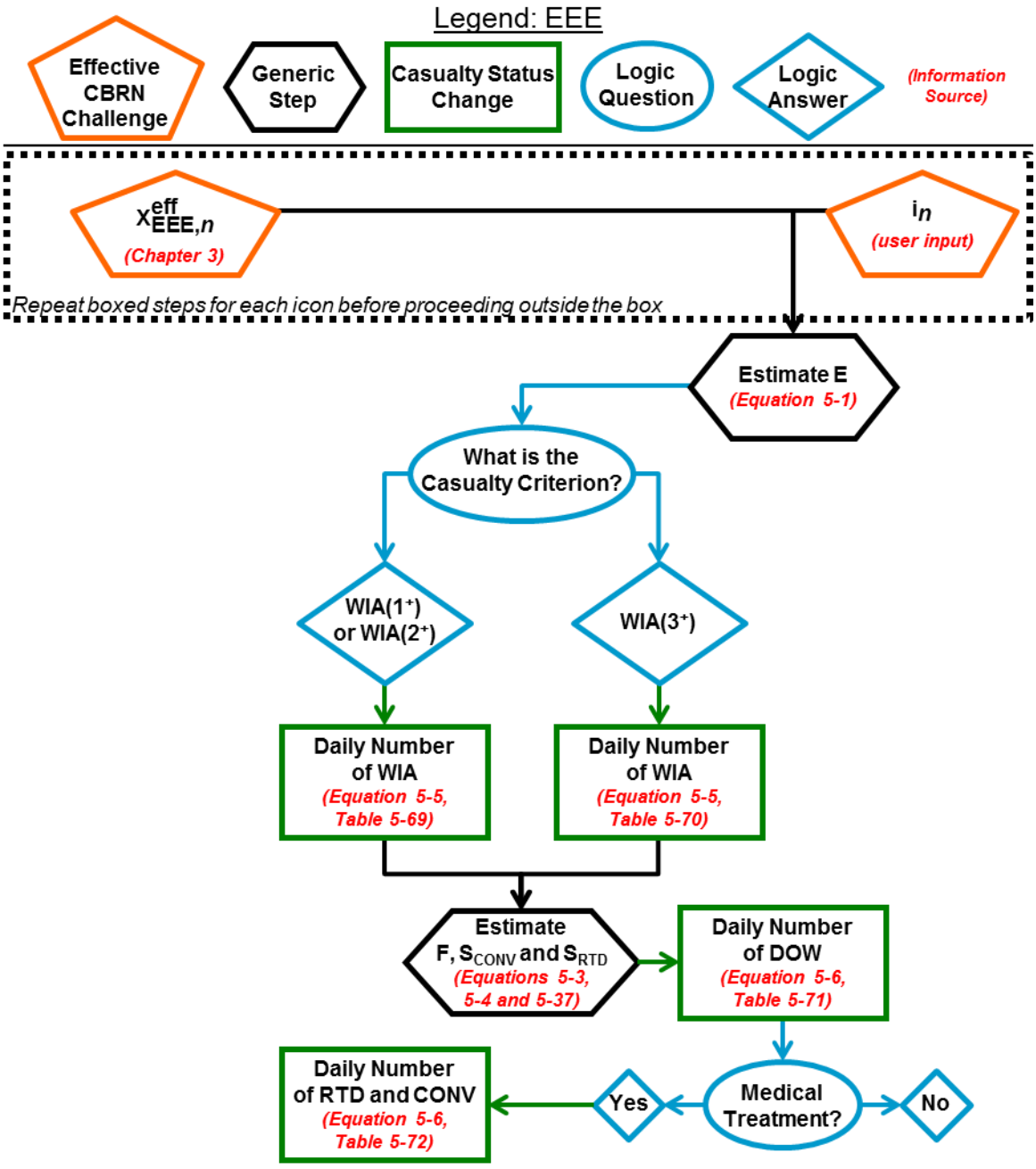


Figure 5-11: Human Response and Casualty Estimation Flowchart for EEE

5.2.14. Venezuelan Equine Encephalitis (VEE)

1. Figure 5-12 summarizes the human response and casualty estimation processes for VEE, Table 5-73 summarizes the Injury Profile, and Table 5-74 summarizes the other VEE submodels. No prophylaxis is modeled for VEE.

2. Cohorts and special considerations.

   a. Medical treatment has no effect on the submodel parameter values, so the value of $Flag_{MT}$ only determines whether RTD is estimated.

   b. VEE does not cause any fatalities, so there is no F cohort; only the E and S cohorts are used.

3. Assumptions.

   a. For threshold infectivity model: all inhaled VEE virus is retained.

   b. VEE is nonlethal in all cases, even without treatment.

4. Table 5-75 through Table 5-76 are the PDTs for VEE. The values from a given table are to be used in Equation 5-5 or 5-6 with the cohort listed in the table header.

Table 5-73: VEE Injury Profile

Stage	Injury Severity Level
1	3
2	2
3	1

Table 5-74: VEE Submodel Summary

Type	Parameter Values (basis of derived values)
Infectivity ($p_F(X^{eff}_{VEE,n})$)	
Threshold	1 PFU
Lethality (p_f(VEE))	
CFR	0%
Incubation Period*	
Weibull Distribution	α = 1.60; β = 2.16 (mean = 1.94 days; standard deviation = 1.24 days)
Duration of Illness*	
Stage 1: All (S)	
Discrete	x = [2, 3], p = [0.8, 0.2]
Stage 2: All (S)	
Lognormal Distribution	μ = 0.993; σ = 0.708 (mean = 3.47 days; standard deviation = 2.80 days)
Stage 3: All (S)	
Lognormal Distribution	μ = 1.336; σ = 0.694 (mean = 4.84 days; standard deviation = 3.81 days)

* Presented for information only. These two submodels have already been convolved to generate the PDTs; the user should use the PDTs to estimate when changes in casualty category occur.

Table 5-75: Daily Fraction of Individuals Ill with VEE (E) Who Become WIA, for Any Casualty Criterion

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.2530	3	0.2288	5	0.0468	7	0.0045	9	0.0003
2	0.3340	4	0.1157	6	0.0158	8	0.0011	≥10	0.0000

Table 5-76: Daily Fraction of VEE Survivors (S) Who Become RTD

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0000	12	0.1000	23	0.0089	34	0.0008	45	0.0001
2	0.0000	13	0.0871	24	0.0070	35	0.0007	46	0.0001
3	0.0000	14	0.0729	25	0.0056	36	0.0006	47	0.0001
4	0.0002	15	0.0595	26	0.0044	37	0.0005	48	0.0001
5	0.0037	16	0.0477	27	0.0035	38	0.0004	49	0.0001
6	0.0175	17	0.0378	28	0.0028	39	0.0003	50	0.0001
7	0.0435	18	0.0297	29	0.0023	40	0.0003	51	0.0001
8	0.0735	19	0.0233	30	0.0018	41	0.0002	52	0.0001
9	0.0972	20	0.0183	31	0.0015	42	0.0002	≥53	0.0000
10	0.1088	21	0.0143	32	0.0012	43	0.0002		
11	0.1086	22	0.0113	33	0.0010	44	0.0001		

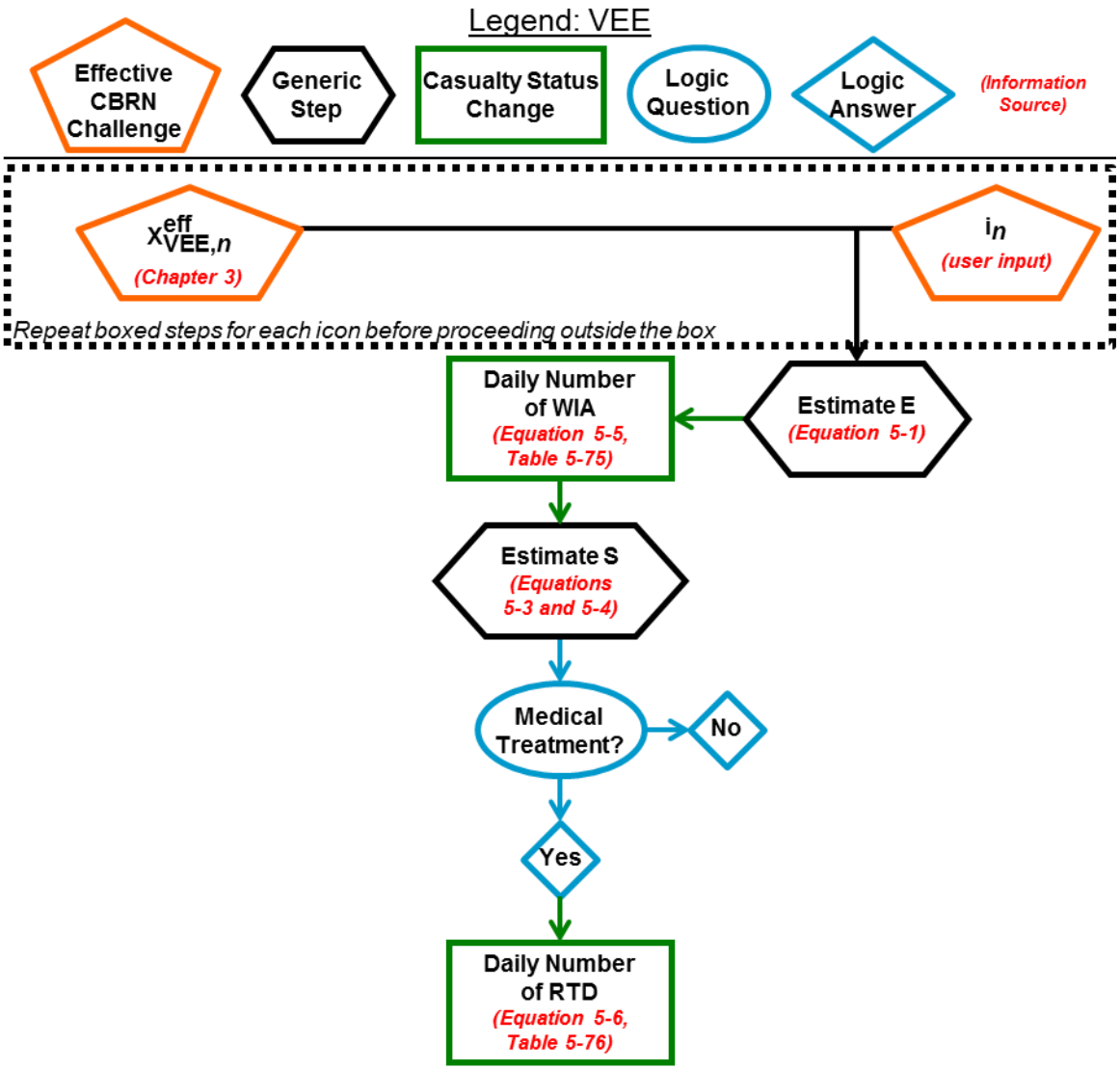


Figure 5-12: Human Response and Casualty Estimation Flowchart for VEE

5.2.15. Western Equine Encephalitis (WEE)

1. Figure 5-13 summarizes the human response and casualty estimation processes for WEE, Table 5-77 summarizes the Injury Profile, and Table 5-78 summarizes the other WEE submodels. No prophylaxis is modeled for WEE.

2. Cohorts and special considerations.

   a. Medical treatment has no effect on the submodel parameter values, so the value of $Flag_{MT}$ only determines whether CONV and RTD are estimated.

   b. The E, F, and S cohorts are used.

3. Assumptions.

a. Inhalation of WEE virus results in encephalitic disease.

b. All strains can be represented by a single set of model parameter values.

4. Table 5-79 through Table 5-82 are the PDTs for WEE. The values from a given table are to be used in Equation 5-5 or 5-6 with the cohort listed in the table header.

Table 5-77: WEE Injury Profile

Stage	Injury Severity Level
1	2
2	3
3	3

Table 5-78: WEE Submodel Summary

Type	Parameter Values (basis of derived values)
Infectivity ($p_E(X^{eff}_{WEE,n})$)	
Threshold	$1.78 \cdot 10^6$ PFU
Lethality (p_f(WEE))	
CFR	25%
Incubation Period*	
Lognormal Distribution	μ = 1.530; σ = 0.190 (mean = 4.7 days; standard deviation = 0.9 days)
Duration of Illness*	
Stage 1: All (F and S)	
Lognormal Distribution	μ = 1.351; σ = 0.411 (mean = 4.2 days; standard deviation = 1.8 days)
Stages 2 and 3 (total): Non-survivors (F) Stage 2: Survivors (S)	
Lognormal Distribution	μ = 1.438; σ = 0.586 (mean = 5.0 days; standard deviation = 3.2 days)
Stage 3: Survivors (S)	
Constant	14 days

* Presented for information only. These two submodels have already been convolved to generate the PDTs; the user should use the PDTs to estimate when changes in casualty category occur.

Table 5-79: Daily Fraction of Individuals Ill with WEE (E) Who Become WIA, for Casualty Criterion WIA(1^+) or WIA(2^+)

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0000	4	0.2136	7	0.0694	10	0.0002
2	0.0000	5	0.4380	8	0.0122	≥11	0.0000
3	0.0116	6	0.2534	9	0.0017		

Table 5-80: Daily Fraction of Individuals Ill with WEE (E) Who Become WIA, for Casualty Criterion WIA(3^+)

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0000	6	0.0332	11	0.1115	16	0.0049	21	0.0002
2	0.0000	7	0.1195	12	0.0645	17	0.0025	22	0.0001
3	0.0000	8	0.2051	13	0.0350	18	0.0013	23	0.0001
4	0.0000	9	0.2185	14	0.0183	19	0.0007	24	0.0001
5	0.0029	10	0.1717	15	0.0095	20	0.0004	≥25	0.0000

Table 5-81: Daily Fraction of WEE Non-Survivors (F) Who DOW

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0000	10	0.0673	19	0.0338	28	0.0019	37	0.0002
2	0.0000	11	0.1031	20	0.0246	29	0.0014	38	0.0001
3	0.0000	12	0.1254	21	0.0177	30	0.0011	39	0.0001
4	0.0000	13	0.1295	22	0.0128	31	0.0008	40	0.0001
5	0.0000	14	0.1191	23	0.0092	32	0.0006	41	0.0001
6	0.0001	15	0.1008	24	0.0067	33	0.0005	42	0.0001
7	0.0014	16	0.0805	25	0.0049	34	0.0004	43	0.0001
8	0.0094	17	0.0618	26	0.0035	35	0.0003	≥44	0.0000
9	0.0317	18	0.0461	27	0.0026	36	0.0002		

Table 5-82: Daily Fraction of WEE Survivors (S) Who Become RTD

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
15	0.0000	24	0.0673	33	0.0338	42	0.0019	51	0.0002
16	0.0000	25	0.1031	34	0.0246	43	0.0014	52	0.0001
17	0.0000	26	0.1254	35	0.0177	44	0.0011	53	0.0001
18	0.0000	27	0.1295	36	0.0128	45	0.0008	54	0.0001
19	0.0000	28	0.1191	37	0.0092	46	0.0006	55	0.0001
20	0.0001	29	0.1008	38	0.0067	47	0.0005	56	0.0001
21	0.0014	30	0.0805	39	0.0049	48	0.0004	57	0.0001
22	0.0094	31	0.0618	40	0.0035	49	0.0003	≥58	0.0000
23	0.0317	32	0.0461	41	0.0026	50	0.0002		

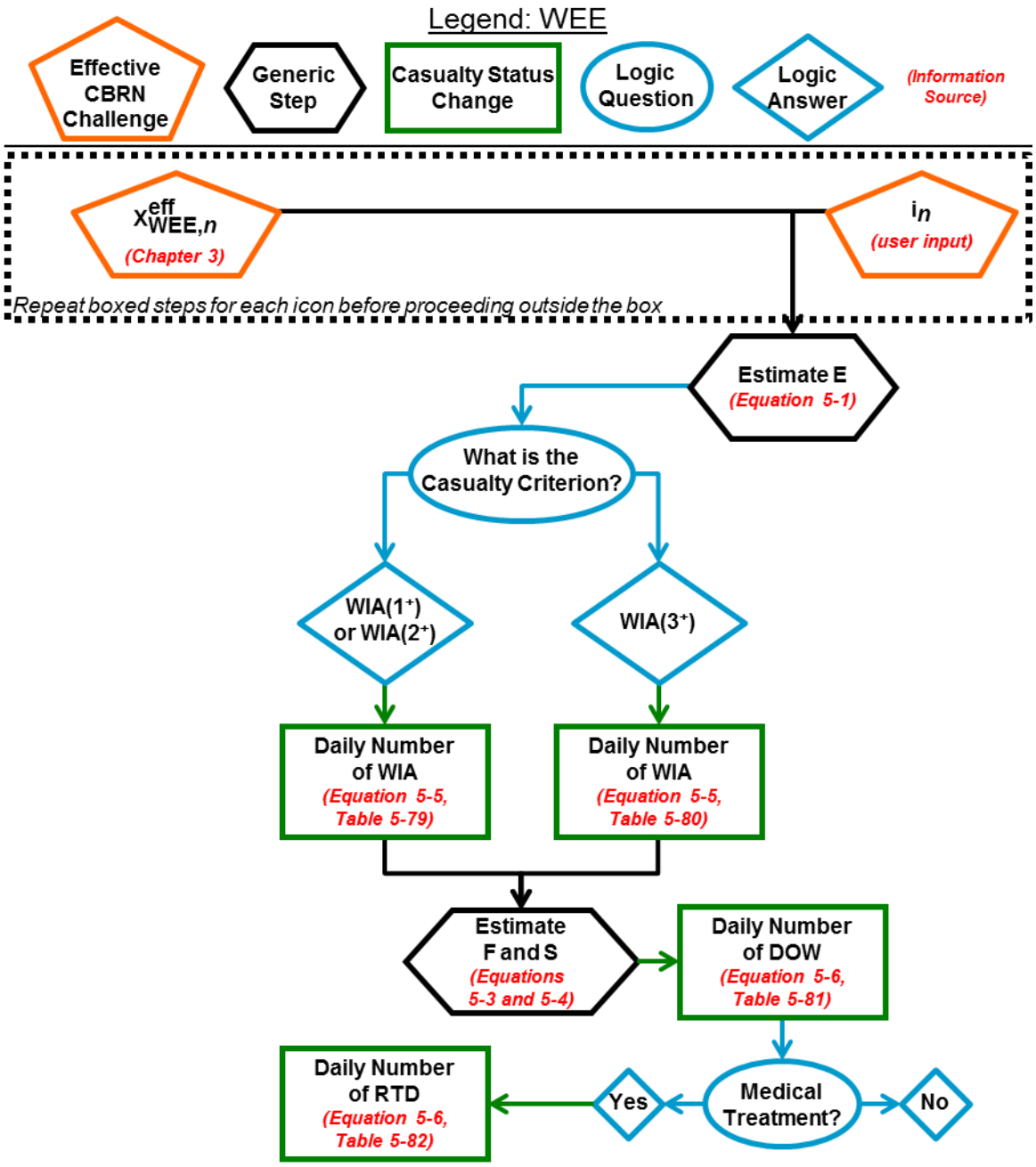


Figure 5-13: Human Response and Casualty Estimation Flowchart for WEE

5.2.16. Botulism

1. Figure 5-14 summarizes the human response and casualty estimation processes for botulism, Table 5-86 summarizes the Injury Profile, Table 5-88 summarizes the other botulism submodels, and Table 5-38 summarizes the available botulism prophylaxis options.

2. Cohorts and special considerations.

   a. If $Flag_{MT}$ = No, the number of people estimated to die according to the untreated lethality model are moved from E into F_U, and the remainder move into S_U (according to Equations 5-2 and 5-4).

   b. If $Flag_{MT}$ = Yes, the E cohort is split among several sub-cohorts, based on the user's chosen day on which antitoxin becomes available ($d_{trt\text{-}bot}$).

      1) E is first split between those who inhaled a dose that is lethal in absence of antitoxin (E_{leth}) and those who inhaled an effective, but not lethal, dose (S_{eff}), based on the untreated, dose-dependent lethality model (Table 5-88) and Equations 5-2 and 5-4. The sub-lethal dose treated sub-cohort (S_{eff}) remains separate from the sub-cohorts described below.

      2) Individuals in the E_{leth} sub-cohort are assumed to require respiratory support ("ventilation") if they do not receive antitoxin prior to reaching Stage 3 of botulism. The exact method by which E_{leth} is divided among several sub-cohorts is dependent on the casualty criterion.

      3) Regardless of the casualty criterion, the following logic and Equations 5-38 to 5-40 are applied to calculate the populations of three sub-cohorts.

         a) Individuals who have already died by $d_{trt\text{-}bot}$ are placed in the F_U sub-cohort (untreated non-survivors).

         b) Individuals in Stage 3 on $d_{trt\text{-}bot}$ are split between the S_{vent} (treated ventilated survivor) and F_{vent} (treated ventilated non-survivor) sub-cohorts, based on the treated lethality model (Table 5-88).

$$F_U = E_{leth} \cdot P_{DOW} \tag{5-38}$$

$$F_{vent} = E_{leth} \cdot 0.12 \cdot P_{in\text{-}Stg3} \tag{5-39}$$

$$S_{vent} = E_{leth} \cdot 0.88 \cdot P_{in\text{-}Stg3} \tag{5-40}$$

      4) If the casualty criterion is WIA(1^+) or WIA(2^+), individuals who have not yet reached Stage 3 on $d_{trt\text{-}bot}$ are placed in one of two treated unventilated survivor sub-cohorts, based on whether they are Stage 1 or the latent period ($S_{unvent\text{-}1}$), or Stage 2 ($S_{unvent\text{-}2}$). Equations 5-41 and 5-42 are applied to calculate the populations of these final two sub-cohorts.

$$S_{unvent\text{-}2} = E_{leth} \cdot P_{in\text{-}Stg2} \tag{5-41}$$

$$S_{unvent\text{-}1} = E_{leth} - F_U - F_{vent} - S_{vent} - S_{unvent\text{-}2} \quad (5\text{-}42)$$

5) If the casualty criterion is WIA(3^+), anyone not already dead or in Stage 3 on $d_{trt\text{-}bot}$ is lumped together in $S_{unvent\text{-}2}$ (using Equation 5-43) because regardless of whether an individual is in the latent period, Stage 1, or Stage 2 on $d_{trt\text{-}bot}$, they will not receive antitoxin until they are declared WIA upon entering Stage 2.

$$S_{unvent\text{-}2} = E_{leth} - F_U - F_{vent} - S_{vent} \quad (5\text{-}43)$$

In Equations 5-38 to5-43:

P_{DOW} is the probability that an individual in the E_{leth} cohort is DOW on $d_{trt\text{-}bot}$ (see Table 5-83), and

$P_{in\text{-}Stg3}$ is the probability that an individual in the E_{leth} cohort is in Stage 3 on $d_{trt\text{-}bot}$ (see Table 5-84), and

$P_{in\text{-}Stg2}$ is the probability that an individual in the E_{leth} cohort is in Stage 2 on $d_{trt\text{-}bot}$ (see Table 5-85).

Table 5-83: Probability That an Individual in the E_{leth} Cohort is DOW On $d_{trt\text{-}bot}$ (P_{DOW})

$d_{trt\text{-}bot}$	P_{DOW}	$d_{trt\text{-}bot}$	P_{DOW}	$d_{trt\text{-}bot}$	P_{DOW}	$d_{trt\text{-}bot}$	P_{DOW}	$d_{trt\text{-}bot}$	P_{DOW}
0	0.0000	5	0.6466	10	0.9731	15	0.9976	20	0.9996
1	0.0064	6	0.7785	11	0.9841	16	0.9984	21	0.9997
2	0.0862	7	0.8664	12	0.9904	17	0.9989	22	0.9998
3	0.2620	8	0.9212	13	0.9941	18	0.9992	23	0.9999
4	0.4677	9	0.9540	14	0.9963	19	0.9994	≥24	1.0000

Table 5-84: Probability That an Individual in the E_{leth} Cohort is in Stage 3 of Botulism On $d_{trt\text{-}bot}$ ($P_{in\text{-}Stg3}$)

Day $d_{trt\text{-}bot}$	$P_{in\text{-}Stg3}$	Day $d_{trt\text{-}bot}$	$P_{in\text{-}Stg3}$	Day $d_{trt\text{-}bot}$	$P_{in\text{-}Stg3}$	Day $d_{trt\text{-}bot}$	$P_{in\text{-}Stg3}$	Day $d_{trt\text{-}bot}$	$P_{in\text{-}Stg3}$
0	0.0000	5	0.1643	10	0.0151	15	0.0011	20	0.0002
1	0.0297	6	0.1139	11	0.0087	16	0.0007	21	0.0002
2	0.1432	7	0.0729	12	0.0051	17	0.0005	22	0.0002
3	0.2141	8	0.0443	13	0.0030	18	0.0004	23	0.0001
4	0.2089	9	0.0261	14	0.0018	19	0.0003	≥24	0.0000

Table 5-85: Probability That an Individual in the E_{leth} Cohort is in Stage 2 of Botulism On $d_{trt\text{-}bot}$ ($P_{in\text{-}Stg2}$)

Day $d_{trt\text{-}bot}$	$P_{in\text{-}Stg2}$	Day $d_{trt\text{-}bot}$	$P_{in\text{-}Stg2}$	Day $d_{trt\text{-}bot}$	$P_{in\text{-}Stg2}$	Day $d_{trt\text{-}bot}$	$P_{in\text{-}Stg2}$	Day $d_{trt\text{-}bot}$	$P_{in\text{-}Stg2}$
0	0.0000	5	0.1100	10	0.0063	15	0.0005	20	0.0001
1	0.1219	6	0.0644	11	0.0036	16	0.0003	21	0.0001
2	0.2580	7	0.0363	12	0.0021	17	0.0002	≥22	0.0000
3	0.2441	8	0.0202	13	0.0013	18	0.0001		
4	0.1750	9	0.0112	14	0.0008	19	0.0001		

3. Assumptions, limitations, and constraints.

   a. Assumption. All individuals are 70-kilogram males.

   b. Limitation. Although the model requires the user to specify a day on which the antitoxin becomes available ($d_{trt\text{-}bot}$), it does *not* apply the antitoxin to every person on that day; only those who have been declared WIA are modeled to receive antitoxin on that day. Those who are declared WIA after $d_{trt\text{-}bot}$ are modeled to receive the antitoxin on the day they are declared WIA.

   c. Constraints.

      1) The models are based on Serotype A.

      2) Upon receiving antitoxin, individuals are modeled to complete the stage they are already in without modification of that stage's duration of illness due to receiving the antitoxin. The duration(s) of subsequent stages of illness are modified because of the antitoxin.

4. Table 5-89 through Table 5-99 are the PDTs for botulism. The values from a given table are to be used in Equation 5-5 or 5-6 with the cohort(s) listed in the table header.

Table 5-86: Botulism Injury Profile

Stage	Injury Severity Level
Untreated Non-Survivors (F_U) Treated, Ventilated Non-Survivors (F_{vent})	
1	2
2	3
3	4
Untreated Survivors (S_U) Treated, Sub-lethal Dose Survivors (S_{eff}) Treated, Unventilated Survivors ($S_{unvent-1}$ and $S_{unvent-2}$)	
1	2
2	3
3	2
Treated, Ventilated Survivors (S_{vent})	
1	2
2	3
3	4
4	2

Table 5-87: Botulism Prophylaxis Summary

Type of Prophylaxis	Efficacy (ρ_n)
Pre-exposure vaccination	1.00

Table 5-88: Botulism Submodel Summary

Type	Parameter Values (basis of derived values)
Effectivity ($p_F(X^{eff}_{bot,n})$)	
Lognormal Distribution	μ = -2.303; σ = 0.184 (ED_{50} = 0.1 μg; probit slope = 12.5 probits/log(dose))
Lethality	
Untreated ($p_f(X^{eff}_{bot,n})$)	
Lognormal Distribution	μ = -0.223; σ = 0.184 (LD_{50} = 0.8 μg; probit slope = 12.5 probits/log(dose))
Treated with Antitoxin Prior to Stage 3 (p_f(botulism))	
CFR	0%
Treated with Antitoxin After Onset of Stage 3 (p_f(botulism))	
CFR	12%
Latent Period*	
Lognormal Distribution	μ = 0.000; σ = 0.840 (mean = 1.42 days; standard deviation = 1.44 days)
Duration of Illness*	
Stage 1: Survivors, Untreated (S_U) Stage 1: Survivors, Treated, Sub-lethal Dose (S_{eff})	
Constant	1 day
Stage 2: Survivors, Untreated (S_U)	
Constant	14 days
Stage 3: Survivors, Untreated (S_U) Stage 3: Survivors, Treated, Sub-lethal Dose (S_{eff})	
Constant	180 days
Stage 2: Survivors, Treated, Sub-lethal Dose (S_{eff}) Stage 2: Survivors, Stage 1 Treated Unventilated ($S_{unvent-1}$)	
Constant	7 days
Stage 3: Survivors, Stage 1 Treated Unventilated ($S_{unvent-1}$) Stage 3: Survivors, Stage 2 Treated Unventilated ($S_{unvent-2}$)	
Constant	270 days
Stages 1, 2, and 3 (each): Non-Survivors, Untreated (F_U) Stages 1 and 2 (each): Non-Survivors, Treated Ventilated (F_{vent}) Stages 1 and 2 (each): Survivors, Treated Ventilated (S_{vent}) Stage 1: Survivors, Stage 1 Treated Unventilated ($S_{unvent-1}$) Stages 1 and 2 (each): Survivors, Stage 2 Treated Unventilated ($S_{unvent-2}$)	
Exponential Distribution	λ = 0.954 (mean = 1.04 days)
Stage 3: Non-Survivors, Treated Ventilated (F_{vent}) Stage 3: Survivors, Treated Ventilated (S_{vent})	
Constant	70 days
Stage 4: Survivors, Treated Ventilated (S_{vent})	
Constant	Indefinite

* Presented for information only. These two submodels have already been convolved to generate the PDTs; the user should use the PDTs to estimate when changes in casualty category occur.

Table 5-89: Daily Fraction of Individuals Ill with Botulism (E) Who Become WIA, for Casualty Criterion WIA(1^+) or WIA(2^+)

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.5000	6	0.0112	11	0.0009	16	0.0002	≥21	0.0000
2	0.2954	7	0.0062	12	0.0006	17	0.0001		
3	0.1092	8	0.0036	13	0.0004	18	0.0001		
4	0.0460	9	0.0022	14	0.0003	19	0.0001		
5	0.0218	10	0.0014	15	0.0002	20	0.0001		

Table 5-90: Daily Fraction of Untreated Non-Survivors (F_U), Treated Ventilated Non-Survivors (F_{vent}), Treated Ventilated Survivors (S_{vent}) , and Stage 2 Treated Unventilated Survivors ($S_{unvent-2}$) Ill with Botulism Who Become WIA, for Casualty Criterion WIA(3^+)

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.1580	6	0.0359	11	0.0019	16	0.0002	21	0.0001
2	0.3294	7	0.0188	12	0.0012	17	0.0002	≥22	0.0000
3	0.2328	8	0.0101	13	0.0008	18	0.0001		
4	0.1314	9	0.0056	14	0.0005	19	0.0001		
5	0.0693	10	0.0032	15	0.0003	20	0.0001		

Table 5-91: Daily Fraction of Untreated Survivors (S_U) and Treated Sub-lethal Dose Survivors (S_{eff}) Ill with Botulism Who Become WIA, for Casualty Criterion WIA(3^+)

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0000	6	0.0218	11	0.0014	16	0.0002	21	0.0001
2	0.5000	7	0.0112	12	0.0009	17	0.0002	≥22	0.0000
3	0.2954	8	0.0062	13	0.0006	18	0.0001		
4	0.1092	9	0.0036	14	0.0004	19	0.0001		
5	0.0460	10	0.0022	15	0.0003	20	0.0001		

Table 5-92: Daily Fraction of Untreated Botulism Non-Survivors (F_U) Who DOW

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0064	6	0.1319	11	0.0110	16	0.0008	21	0.0001
2	0.0798	7	0.0879	12	0.0063	17	0.0005	22	0.0001
3	0.1758	8	0.0548	13	0.0037	18	0.0003	23	0.0001
4	0.2057	9	0.0328	14	0.0022	19	0.0002	24	0.0001
5	0.1789	10	0.0191	15	0.0013	20	0.0002	≥25	0.0000

Table 5-93: Daily Fraction of Treated Ventilated Botulism Non-Survivors (F_{vent}) Who DOW; Daily Fraction of Treated Ventilated Botulism Survivors (S_{vent}) Who Become CONV

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
≤70	0.0000	75	0.1343	80	0.0081	85	0.0006	90	0.0001
71	0.0361	76	0.0815	81	0.0046	86	0.0004	91	0.0001
72	0.1933	77	0.0469	82	0.0027	87	0.0003	92	0.0001
73	0.2467	78	0.0262	83	0.0016	88	0.0002	≥93	0.0000
74	0.2005	79	0.0146	84	0.0010	89	0.0001		

Table 5-94: Daily Fraction of Treated Sub-lethal Dose Botulism Survivors (S_{eff}) Who Become CONV

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
≤8	0.0000	13	0.0218	18	0.0014	23	0.0002	28	0.0001
9	0.5000	14	0.0112	19	0.0009	24	0.0002	≥29	0.0000
10	0.2954	15	0.0062	20	0.0006	25	0.0001		
11	0.1092	16	0.0036	21	0.0004	26	0.0001		
12	0.0460	17	0.0022	22	0.0003	27	0.0001		

Table 5-95: Daily Fraction of Treated Sub-lethal Dose Botulism Survivors (S_{eff}) Who Become RTD

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
≤188	0.0000	193	0.0218	198	0.0014	203	0.0002	208	0.0001
189	0.5000	194	0.0112	199	0.0009	204	0.0002	≥209	0.0000
190	0.2954	195	0.0062	200	0.0006	205	0.0001		
191	0.1092	196	0.0036	201	0.0004	206	0.0001		
192	0.0460	197	0.0022	202	0.0003	207	0.0001		

Table 5-96: Daily Fraction of Stage 1 Treated Unventilated Botulism Survivors ($S_{unvent-1}$) Who Become CONV

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
≤7	0.0000	12	0.0693	17	0.0032	22	0.0003	27	0.0001
8	0.1580	13	0.0359	18	0.0019	23	0.0002	28	0.0001
9	0.3294	14	0.0188	19	0.0012	24	0.0002	≥29	0.0000
10	0.2328	15	0.0101	20	0.0008	25	0.0001		
11	0.1314	16	0.0056	21	0.0005	26	0.0001		

Table 5-97: Daily Fraction of Stage 1 Treated Unventilated Botulism Survivors ($S_{unvent-1}$) Who Become RTD

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
≤277	0.0000	282	0.0693	287	0.0032	292	0.0003	297	0.0001
278	0.1580	283	0.0359	288	0.0019	293	0.0002	298	0.0001
279	0.3294	284	0.0188	289	0.0012	294	0.0002	≥299	0.0000
280	0.2328	285	0.0101	290	0.0008	295	0.0001		
281	0.1314	286	0.0056	291	0.0005	296	0.0001		

Table 5-98: Daily Fraction of Stage 2 Treated Unventilated Botulism Survivors ($S_{unvent-2}$) Who Become CONV

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
1	0.0361	6	0.0815	11	0.0046	16	0.0004	21	0.0001
2	0.1933	7	0.0469	12	0.0027	17	0.0003	22	0.0001
3	0.2467	8	0.0262	13	0.0016	18	0.0002	≥23	0.0000
4	0.2005	9	0.0146	14	0.0010	19	0.0001		
5	0.1343	10	0.0081	15	0.0006	20	0.0001		

Table 5-99: Daily Fraction of Stage 2 Treated Unventilated Botulism Survivors ($S_{unvent-2}$) Who Become RTD

Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction	Day	Fraction
≤270	0.0000	275	0.1343	280	0.0081	285	0.0006	290	0.0001
271	0.0361	276	0.0815	281	0.0046	286	0.0004	291	0.0001
272	0.1933	277	0.0469	282	0.0027	287	0.0003	292	0.0001
273	0.2467	278	0.0262	283	0.0016	288	0.0002	≥293	0.0000
274	0.2005	279	0.0146	284	0.0010	289	0.0001		

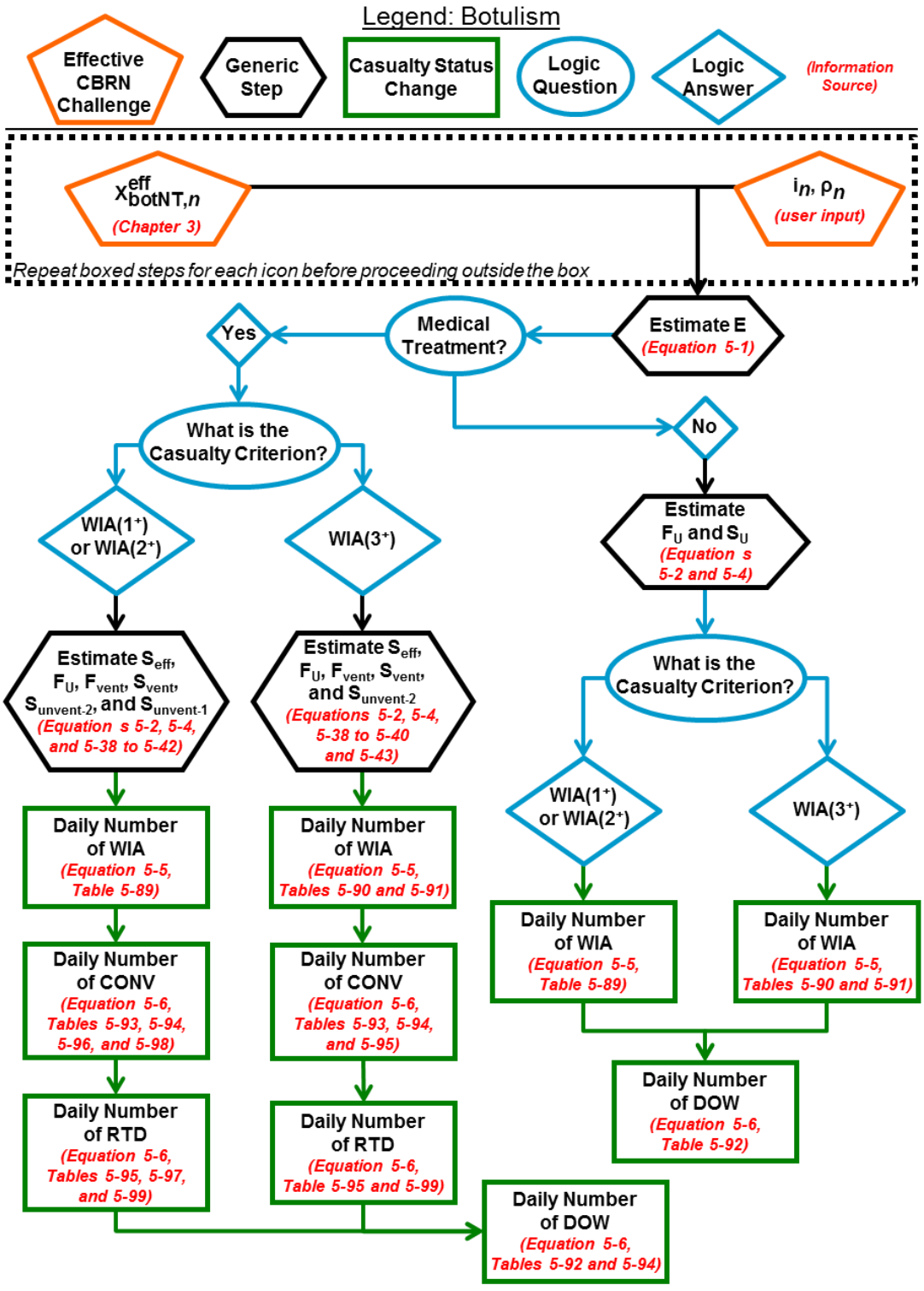


Figure 5-14: Human Response and Casualty Estimation Flowchart for Botulism

5.2.17. Ricin Intoxication

1. Figure 5-15 summarizes the human response and casualty estimation processes for ricin intoxication, Table 5-102 summarizes the Injury Profile, and Table 5-103 summarizes the other ricin intoxication submodels. No prophylaxis is modeled for ricin intoxication.

2. Cohorts and special considerations.

   a. Medical treatment has no effect on the submodel parameter values, so the value of $Flag_{MT}$ only determines whether RTD is estimated.

   b. The duration of illness model is dose-dependent. Since different stages of illness have different dose dependence, there is one set of dose ranges for estimating WIA and another for estimating DOW.

      1) When estimating WIA, the E cohort is split into sub-cohorts labeled as E_{DR}, where DR is the dose range label given in Table 5-100. The population of each E_{DR} is calculated separately for each dose range by applying Equation 5-1 to the appropriate range of doses.

      2) When estimating DOW, the F cohort is split into sub-cohorts labeled as F_{DR}, where DR is the dose range label given in Table 5-101. The population of each F_{DR} is calculated separately for each dose range by applying Equation 5-2 to the appropriate range of doses.

      3) The population of the S cohort is estimated by Equation 5-4 after summing the E_{DR} and F_{DR} sub-cohorts to determine E and F.

Table 5-100: Ricin Intoxication Dose Ranges for the E_{DR} Sub-Cohorts

Dose Range Label	Dose Range (µg)		Dose Range Label	Dose Range (µg)	
	>	≤		>	≤
WIA-A	0	2	WIA-D	11	41
WIA-B	2	4	WIA-E	41	415
WIA-C	4	11	WIA-F	415	

Table 5-101: Ricin Intoxication Dose Ranges for the F_{DR} Sub-Cohorts

Dose Range Label	Dose Range (µg)		Dose Range Label	Dose Range (µg)	
	>	≤		>	≤
DOW-A	0	2	DOW-I	19	30
DOW-B	2	3	DOW-J	30	50
DOW-C	3	4	DOW-K	50	92
DOW-D	4	5	DOW-L	92	193
DOW-E	5	7	DOW-M	193	504
DOW-F	7	9	DOW-N	504	1946
DOW-G	9	13	DOW-O	1946	19619
DOW-H	13	19	DOW-P	19619	

3. Assumptions.

   a. All individuals are 70-kilogram males.

   b. The effectivity probit slope is equal to the lethality probit slope.

4. Table 5-104 through Table 5-107 are the PDTs for ricin intoxication. The values from a given table are to be used in Equation 5-5 or 5-6 with the cohort listed in the table header.

Table 5-102: Ricin Intoxication Injury Profile

Stage	Injury Severity Level
Non-Survivors (F_{DR})	
1	1
2	3
3	4
Survivors (S)	
1	1
2	1

Table 5-103: Ricin Intoxication Submodel Summary

Type	Parameter Values (basis of derived values)
Effectivity ($p_E(X^{eff}_{ricin,n})$)	
Lognormal Distribution	μ = 4.727; σ = 0.235 (ED_{50} = 113 μg; probit slope = 9.8 probits/log(dose))
Lethality ($p_f(X^{eff}_{ricin,n})$)	
Lognormal Distribution	μ = 5.935; σ = 0.235 (LD_{50} = 378 μg; probit slope = 9.8 probits/log(dose))
Latent Period*	
Constant	6 hours
Duration of Illness*	
Stage 1: Non-Survivors (F_{DR})	
Power Function	c = 6.1; r = -0.3
Stage 2: Non-Survivors (F_{DR})	
Power Function	c = 4.3; r = -0.3
Stage 3: Non-Survivors (F_{DR})	
Power Function	c = 9.0; r = -0.3
Stage 1: Survivors (S)	
Power Function	c = 10.4; r = -0.3
Total Duration: Survivors (S)	
Constant	192 hours

* Presented for information only. These two submodels have already been convolved to generate the PDTs; the user should use the PDTs to estimate when changes in casualty category occur.

Table 5-104: Daily Fraction of Individuals Ill with Ricin Intoxication (E_{DR}) Who Become WIA, for WIA(1^+)

Day	Fraction
1	1.0000
≥2	0.0000

Table 5-105: Dose-Dependent Day on Which Individuals Ill with Ricin Intoxication (E_{DR}) Become WIA, for WIA(2^+) or WIA(3^+)

Day	Dose Range	Day	Dose Range	Day	Dose Range
≥7	(none)	4	WIA-C	1	WIA-F
6	WIA-A	3	WIA-D		
5	WIA-B	2	WIA-E		

Table 5-106: Dose-Dependent Day on Which Ricin Intoxication Non-Survivors (F_{DR}) DOW

Day	Dose Range	Day	Dose Range	Day	Dose Range	Day	Dose Range
≥17	(none)	12	DOW-E	7	DOW-J	2	DOW-O
16	DOW-A	11	DOW-F	6	DOW-K	1	DOW-P
15	DOW-B	10	DOW-G	5	DOW-L		
14	DOW-C	9	DOW-H	4	DOW-M		
13	DOW-D	8	DOW-I	3	DOW-N		

Table 5-107: Daily Fraction of Ricin Intoxication Survivors (S) Who Become RTD

Day	Fraction
≤8	0.0000
9	1.0000
≥10	0.0000

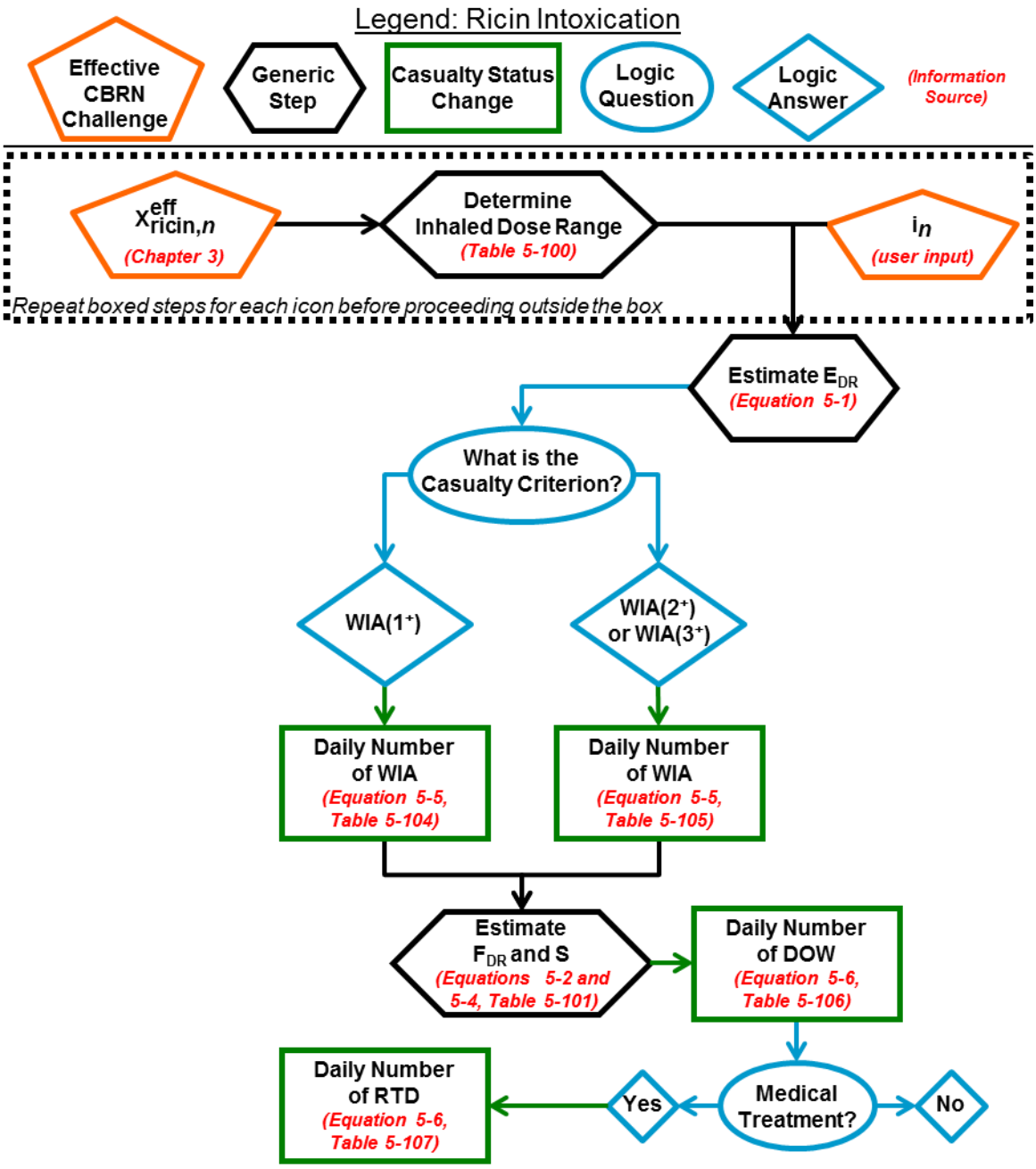


Figure 5-15: Human Response and Casualty Estimation Flowchart for Ricin Intoxication

5.2.18. Staphylococcal Enterotoxin B (SEB) Intoxication

1. Figure 5-16 summarizes the human response and casualty estimation processes for SEB intoxication, Table 5-109 summarizes the Injury Profile, and Table 5-110 summarizes the other SEB intoxication submodels. No prophylaxis is modeled for SEB intoxication.

2. Cohorts and special considerations.

   a. Medical treatment has no effect on the submodel parameter values, so the value of $Flag_{MT}$ only determines whether RTD is estimated.

   b. The SEB intoxication Stage 1 duration of illness model is dose-dependent; Table 5-108 summarizes the dose ranges. The E, F, and S cohorts are split into sub-cohorts labeled as E_{DR}, F_{DR}, and S_{DR}, where DR is the dose range label given in Table 5-108. The population of each E, F, and S sub-cohort is calculated separately for each dose range by applying Equations 5-1, 5-2, and 5-4 to the appropriate range of doses.

Table 5-108: SEB Intoxication Dose Ranges

Dose Range Label	Dose Range (organisms)		Dose Range Label	Dose Range (organisms)	
	>	≤		>	≤
A	0	0.0239	F	0.2824	0.3470
B	0.0239	0.0885	G	0.3470	0.4116
C	0.0885	0.1532	H	0.4116	0.4762
D	0.1532	0.2178	I	0.4762	
E	0.2178	0.2824			

3. Assumptions.

   a. All individuals are 70-kilogram males.

   b. The lethality probit slope is equal to the effectivity probit slope.

4. Table 5-111 through Table 5-113 are the PDTs for SEB. The values from a given table are to be used in Equation 5-5 or 5-6 with the cohort listed in the table header.

Table 5-109: SEB Intoxication Injury Profile

Stage	Injury Severity Level
Non-Survivors (F_{DR})	
1	3
Survivors (S_{DR})	
1	3
2	1

Table 5-110: SEB Intoxication Submodel Summary

Type	Parameter Values (basis of derived values)
Effectivity ($p_F(X^{eff}_{SEB,n})$)	
Lognormal Distribution	μ = -3.650; σ = 0.944 (ED_{50} = 0.026 μg; probit slope = 2.44 probits/log(dose))
Lethality ($p_f(X^{eff}_{SEB,n})$)	
Lognormal Distribution	μ = 0.336; σ = 0.944 (LD_{50} = 1.4 μg; probit slope = 2.44 probits/log(dose))
Latent Period*	
Constant	9 hours
Duration of Illness*	
Stage 1: All (F_{DR} and S_{DR})	
Linear Function	m = 15.48 days/μg; b = 0.254 days (max = 8 days)
Stage 2: All (F_{DR} and S_{DR})	
Constant	7 days

* Presented for information only. These two submodels have already been convolved to generate the PDTs; the user should use the PDTs to estimate when changes in casualty category occur.

Table 5-111: Daily Fraction of Individuals Ill with SEB Intoxication (E_{DR}) Who Become WIA, for Any Casualty Criterion

Day	Fraction
1	1.0000
≥2	0.0000

Table 5-112: Dose-Dependent Day on Which SEB Intoxication Non-Survivors (F_{DR}) DOW

Day	Dose Range	Day	Dose Range	Day	Dose Range	Day	Dose Range
1	A	4	D	7	G	≥10	(none)
2	B	5	E	8	H		
3	C	6	F	9	I		

Table 5-113: Daily Fraction of SEB Intoxication Survivors (S_{DR}) Who Become RTD

Day	Dose Range	Day	Dose Range	Day	Dose Range	Day	Dose Range
≤7	(none)	10	C	13	F	16	I
8	A	11	D	14	G	≥17	(none)
9	B	12	E	15	H		

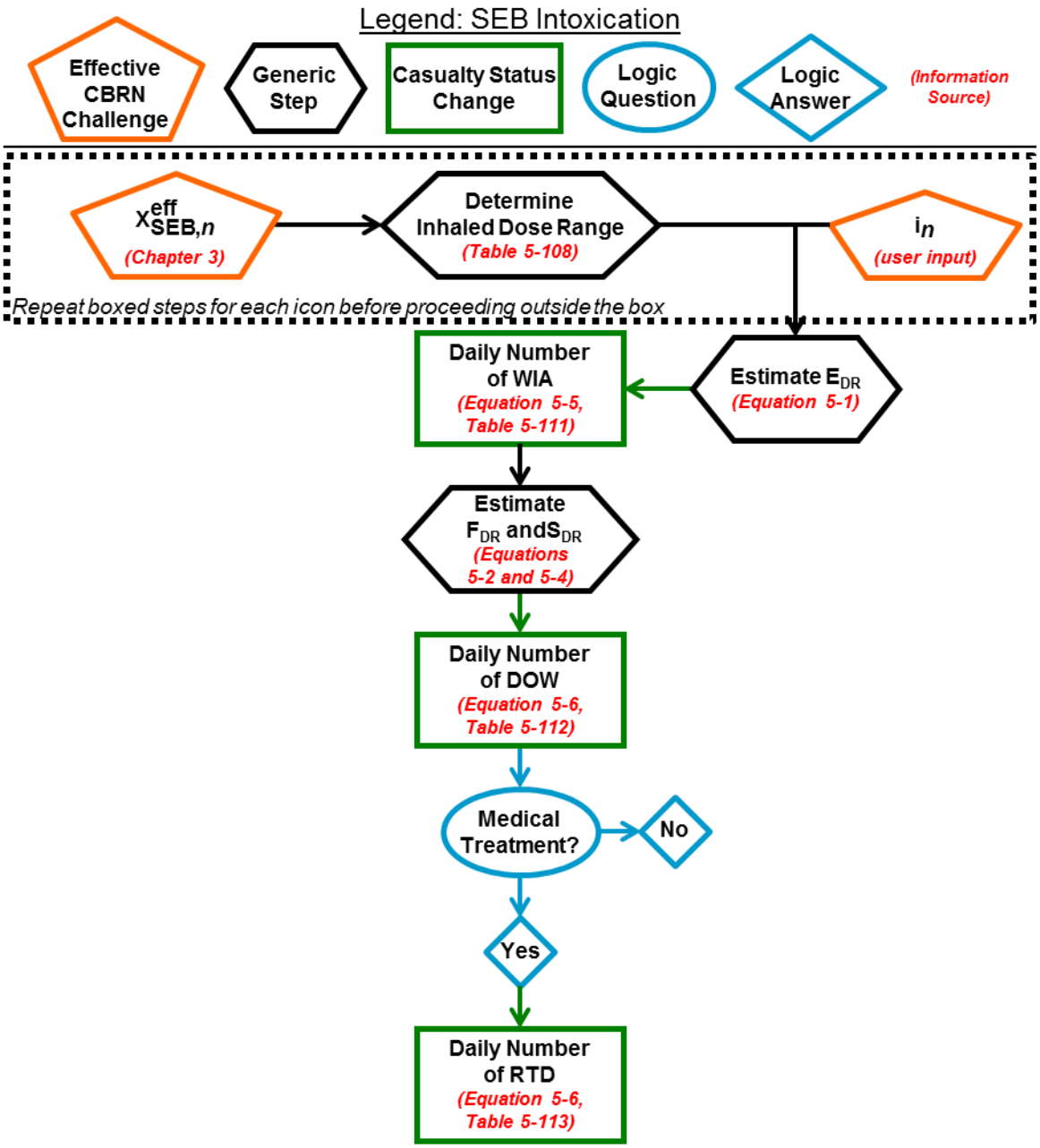


Figure 5-16: Human Response and Casualty Estimation Flowchart for SEB Intoxication

5.2.19. T-2 Mycotoxicosis

1. Figure 5-17 summarizes the human response and casualty estimation processes for T-2 mycotoxicosis, Table 5-114 summarizes the Injury Profile, and Table 5-115 summarizes the other T-2 mycotoxicosis submodels. No prophylaxis is modeled for T-2 mycotoxicosis.

2. Cohorts and special considerations.

   a. Medical treatment has no effect on the submodel parameter values, so the value of $Flag_{MT}$ only determines whether RTD is estimated.

   b. The E, F, and S cohorts are used.

3. Assumptions.

   a. All individuals are 70-kilogram males.

   b. The effectivity probit slope is equal to the lethality probit slope.

4. Table 5-116 through Table 5-119 are the PDTs for T-2 mycotoxicosis. The values from a given table are to be used in Equation 5-5 or 5-6 with the cohort listed in the table header.

Table 5-114: T-2 Mycotoxicosis Injury Profile

Stage	Injury Severity Level
Non-Survivors (F)	
1	2
2	3
3	4
Survivors (S)	
1	2
2	3

Table 5-115: T-2 Mycotoxicosis Submodel Summary

Type	Parameter Values (basis of derived values)
Effectivity ($p_E(X^{eff}_{T\text{-}2,n})$)	
Lognormal Distribution	μ = 3.135; σ = 0.535 (ED_{50} = 23 mg; probit slope = 4.3 probits/log(dose))
Lethality ($p_f(X^{eff}_{T\text{-}2,n})$)	
Lognormal Distribution	μ = 3.332; σ = 0.535 (LD_{50} = 28 mg; probit slope = 4.3 probits/log(dose))
Latent Period*	
Constant	4 hours
Duration of Illness*	
Stage 1: Non-Survivors (F) Stage 1: Survivors (S)	
Constant	8 hours
Stages 2 and 3: Non-survivors (F)	
Constant	4 hours
Stage 2: Survivors (S)	
Constant	18 days

* Presented for information only. These two submodels have already been convolved to generate the PDTs; the user should use the PDTs to estimate when changes in casualty category occur.

Table 5-116: Daily Fraction of Individuals Ill with T-2 Mycotoxicosis (E) Who Become WIA, for WIA(1^+) or WIA(2^+)

Day	Fraction
1	1.0000
≥2	0.0000

Table 5-117: Daily Fraction of Individuals Ill with T-2 Mycotoxicosis (E) Who Become WIA, for WIA(3^+)

Day	Fraction
1	1.0000
≥2	0.0000

Table 5-118: Daily Fraction of T-2 Mycotoxicosis Non-Survivors (F) Who DOW

Day	Fraction
1	1.0000
≥2	0.0000

Table 5-119: Daily Fraction of T-2 Mycotoxicosis Survivors (S) Who Become RTD

Day	Fraction	Day	Fraction
≤14	0.0000	≥15	0.0000
15	1.0000		

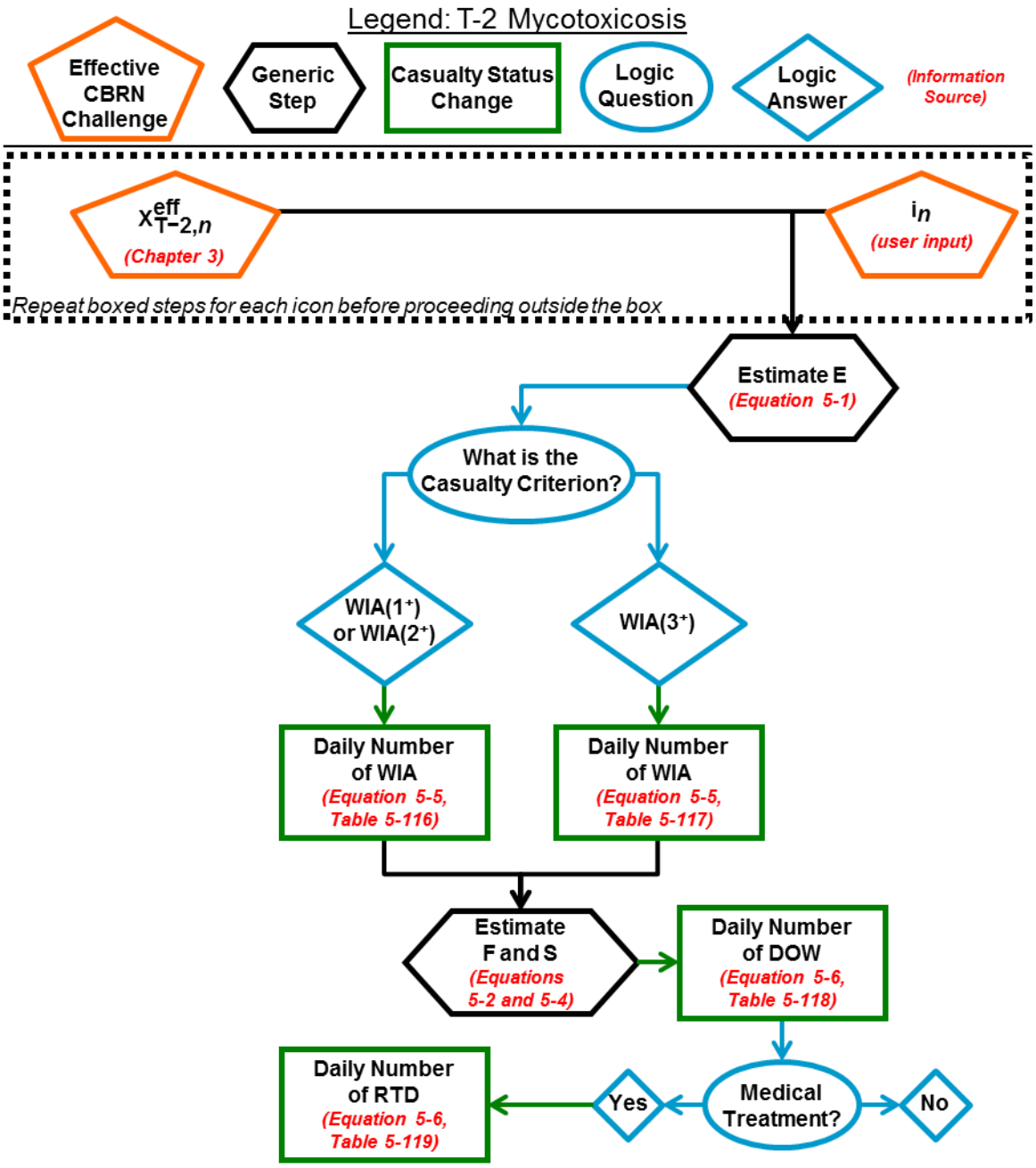


Figure 5-17: Human Response and Casualty Estimation Flowchart for T-2 Mycotoxicosis

CHAPTER 6 CASUALTY SUMMATION AND REPORTING

This chapter explains how the methodology's outputs meet the requirements of AJP-4.10, and how the casualty estimate tables are generated from the outputs of Chapters 4 and 5. For specific guidance on how the outputs might be used, see AMedP-7.6. For additional operational, logistic, and medical planning considerations that may be affected by CBRN casualty estimates, see AJP-5, AJP-4, and AJP-4.10, respectively.

6.1. APPLICATION OF AJP-4.10 REQUIREMENTS

1. As stated in AJP-4.10, the casualty estimation process should generate four outputs: population at risk (PAR), casualty rates, casualty flow, and casualty profile.

2. In this methodology, the PAR is simply the total number of personnel included in the scenario, which is defined by user input and calculated according to 6-1. The user's determination of which personnel should be included in a scenario should be guided by operational and medical considerations; AMedP-7.6 provides guidance on choosing the PAR.

$$\text{PAR} = \sum_{n} i_n \,, \tag{6-1}$$

where i_n is the number of individuals in icon *n*.

3. The casualty rate is concerned with the number of new casualties of each type per day. AJP-4.10 requires that it be reported in two formats: number per 100 of the PAR per day, and number per day. This methodology produces one table for each output format.

4. The flow characterizes the movement between casualty categories.[74] The casualty flow is depicted within the output tables; a separate table presenting the flow would be redundant.

5. The profile is a description of the relative proportions of types of injuries that cause an individual to become a casualty. Profiles are presented within the output tables. Because different planning considerations are relevant for each casualty

[74] AJP-4.10 also describes flow as characterizing the timing of casualty waves. This is dependent on when incidents occur, which is beyond the purview of this methodology.

category, each category has a unique set of compartments that are used to describe the profile. See Table 6-1 for a summary of the compartments and the list below for explanation.

a. For KIA and DOW, the planning consideration is whether the human remains require special handling that would impact the operations of Mortuary Affairs. KIAs might be contaminated with chemical or radiological materials. DOWs might be biohazards (chemical and radiological casualties should be decontaminated prior to entering an MTF).

b. For WIA and CONV, the planning consideration is the medical resources required to care for the casualty. Thus, WIA is reported based on the challenge and the injury severity level; for example, GB(3) or anthrax(2). CONV is reported only by the challenge.

c. RTD is not compartmented because, by definition, RTD personnel are capable of resuming normal duties.

Table 6-1: Compartments for Reporting Casualty Profile

Category	Basis for Compartments, or Specific Compartment Names
KIA	*Names*: chemical (C), radiological (R), or nuclear (N)
WIA	*Basis*: challenge and Injury Severity Level
DOW	*Names*: biological (B) or chemical/radiological/nuclear (CRN)
CONV	*Basis*: challenge
RTD	None

6.2. DESCRIPTION OF OUTPUT REPORTING

1. The casualty estimate is reported with a time resolution of one day. This time resolution is not user-tunable. Daily reporting continues until no more changes in casualty category occur.

2. The output tables report WIA as a function of the Injury Severity Level at the time individuals are declared WIA. They *do not* track subsequent changes in Injury Severity Level. Thus, once a casualty is counted as WIA, he will not be counted again until he becomes DOW, CONV, or RTD.

3. Since it is possible for an individual to be assigned to multiple casualty categories within a *single* day, the rules below are followed to facilitate more appropriate resource planning and to avoid double-counting. Adherence to these rules is built into the equations in Chapters 4 and 5.

a. An individual who is WIA and then KIA is reported as KIA.

b. An individual who is WIA and then DOW is reported as WIA.

c. An individual who is WIA and then CONV or RTD is reported as WIA.

d. An individual who is CONV and then RTD is reported as CONV.

e. On following day, the casualty's chronologically *later* status is reported. Thus, a WIA—KIA is reported as KIA on the following day, a WIA—DOW/CONV/RTD is reported as DOW/CONV/RTD on the following day, and a CONV—RTD is reported as RTD on the following day.

4. Table 6-2 and Table 6-3 are example output tables. Note that for any particular incident, the tables may look different, depending on the challenge type, the casualty criterion, and the value of $Flag_{MT}$.

a. An incident may involve multiple challenge types (see Section 6.3).

b. The specific compartment labels will be different for different challenge types (as specified in Table 6-1).

c. Certain WIA rows are excluded if the challenge never causes injuries of that Injury Severity Level.

d. Certain WIA rows are excluded if the casualty criterion is such that WIA will not occur at that Injury Severity Level.

Table 6-2: Estimated Daily Number of (Challenge) Casualties per 100 of the PAR (PAR = X), for Casualty Criterion WIA(1^+)*

Casualty Description	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day …	Day X
Daily New Fatality Rates											
KIA—[compartment]											
DOW—[compartment]											
Sum of New Fatality Rates											
Daily New WIA Rates*											
Challenge (mild)											
Challenge (moderate)											
Challenge (severe)											
Challenge (very severe)											
Sum of New WIA Rates											
Daily New CONV Rates											
Sum of New CONV Rates											
Daily New RTD Rate											
Sum of New RTD Rates											

* If the casualty criterion was WIA(2^+) or WIA(3^+), the WIA rows for mild, or mild and moderate, respectively, would not be reported.

Table 6-3: Estimated Daily Number of (Challenge) Casualties, for Casualty Criterion WIA(1+)*

Casualty Description	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day …	Day X
Daily New Fatalities											
KIA—[compartment]											
DOW—[compartment]											
Sum of New Fatalities											
Daily New WIA*											
Challenge (mild)											
Challenge (moderate)											
Challenge (severe)											
Challenge (very severe)											
Sum of New WIA											
Daily New CONV											
Sum of New CONV											
Daily New RTD											
Sum of New RTD											

* If the casualty criterion was WIA(2+) or WIA(3+), the WIA rows for mild, or mild and moderate, respectively, would not be reported.

5. Chapters 4 and 5 provide the daily numbers of reported new casualties in each casualty category.

a. For CRN casualties, Equation 4-3 provides the daily numbers.

b. For non-contagious biological casualties, Equations 5-5 and 5-6 provide the daily numbers.

c. For contagious biological casualties, Equations 5-27 and 5-28 provide the daily numbers.

6. Regardless of the source of the daily numbers, the daily numbers per 100 of the PAR are estimated using Equation 6-2.

$$\text{NewPer100}_{\text{CAT}}(d) = \text{New}_{\text{CAT}}(d) \cdot \frac{100}{\text{PAR}}, \qquad (6\text{-}2)$$

where:

$\text{NewPer100}_{\text{CAT}}(d)$ is the number of individuals per 100 of the PAR who enter CAT on day d and remain there until at least the next day (in decimal form),

$New_{CAT}(d)$ is the number of individuals who enter CAT on day d and remain there until at least the next day (rounded to the nearest integer), as reported by Equation 4-3, 5-5, 5-6, 5-27, or 5-28, and

PAR is the population at risk, as calculated in Equation 6-1.

6.3. OUTPUT REPORTING FOR MULTIPLE CHALLENGE TYPES

1. The methodology cannot account for the combined effects of multiple biological challenges or of a biological challenge and a CRN challenge. It has limited capability to account for multiple simultaneous CRN incidents. This capability is described in general below, with an example for the three prompt nuclear effects.

2. A user interested in modeling multiple simultaneous biological agent incidents or a biological incident in combination with a CRN incident must run the model separately for each incident and perform custom post-processing to combine the results. Double-counting some individuals and failing to account for other individuals will be unavoidable because of the population-based nature of the biological human response models.

3. A user interested in modeling multiple simultaneous CRN incidents[75] (or a single nuclear detonation, which will result in three challenges) may do so by using Composite Injury Profiles, which can be generated using Figure 4-1.

a. The Composite Injury Profile must be consulted to determine if and when each icon becomes KIA or WIA.

b. If $Flag_{MT}$ = No, the Composite Injury Profile is also consulted to determine if and when each icon becomes DOW.

c. If $Flag_{MT}$ = Yes, the medical treatment tables for each challenge type are consulted individually to determine the icon's outcome(s). The earliest time at which any of the relevant tables indicates DOW will take precedence, and the latest time at which any of the relevant tables indicates CONV or RTD will take precedence.

d. The design of the output table will depend on the specific scenario and casualty criterion.

[75] Note that although some individual chemical agents, RDDs, and fallout are each associated with more than one challenge type, reporting compartments (see Table 6-1) are based on the agent/effect, not the challenge type. Thus, for example, reporting for a VX incident would not make use of section 6.3—it would be reported using tables in the form of Table 6-2 and Table 6-3.

1) The KIA, DOW, and RTD compartments will not differ from those described in Table 6-1.

2) There will be additional WIA and CONV compartments based on the combinations of injuries possible. The total number of WIA compartments ($N_{Compartments\text{-}WIA}$) is calculated by Equation 6-3.

$$N_{Compartments\text{-}WIA} = 2^{(\sum_Q N_{WIA,ISL,Q})} - 1, \quad (6\text{-}3)$$

where $N_{WIA,ISL,Q}$ is the number of possible Injury Severity Levels at which challenge type Q can cause an icon to be declared WIA (depends on the casualty criterion and the Injury Profile).

4. Table 6-4 is an example output table for the three nuclear effects.

Table 6-4: Estimated Daily Number of Nuclear Casualties, for Casualty Criterion WIA(1+)*

Casualty Description	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day ...	Day X
Daily New Fatalities											
KIA—U											
DOW—U											
Sum of New Fatalities											
Daily New WIA											
Up to 511 rows covering all combinations of injuries.*											
Radiation can cause WIA at the Mild, Moderate, and Severe levels.											
Blast can cause WIA at the Moderate, Severe, and Very Severe levels.											
Thermal can cause WIA at the Mild, Moderate, and Severe levels.											
Sum of New WIA											
Daily New CONV											
Radiation CONV											
Blast CONV											
Thermal CONV											
Radiation and Blast CONV											
Radiation and Thermal CONV											
Blast and Thermal CONV											
Radiation, Blast, and Thermal CONV											
Sum of New CONV											
Daily New RTD											
Sum of New RTD											

* If the casualty criterion was WIA(2+) or WIA(3+), fewer WIA rows would be reported.

ANNEX A ILLUSTRATIVE EXAMPLES

As of Study Draft 3, this annex will contain illustrative examples, similar to what is in Annex B of AMedP-8(C).

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LIST OF ACRONYMS AND ABBREVIATIONS

AAP	Allied Administration Publication
AC	Hydrogen cyanide
ACH	Air changes per hour
AJP	Allied Joint Publication
AMedP	Allied Medical Publication
BDO	Battle dress overgarment
BDU	Battle dress uniform
CBRN	Chemical, biological, radiological and nuclear
CDF	Cumulative distribution function
CFU	Colony forming unit
CG	Phosgene
CK	Cyanogen chloride
Cl_2	Chlorine
ColPro	Collective protection
CRN	Chemical, radiological and nuclear
Ct	Concentration time
DOW	Died of wounds
DRF	Dose-reduction factor
ECt_{50}	Effective median dosage (concentration time)
ED_{50}	Median effective dose
EEE	Eastern equine encephalitis
GB	Sarin
Gy	Gray
H_2S	Hydrogen sulfide
HD	Distilled mustard
HPAC	Hazard Prediction and Assessment Capability
hr	Hour
ID_{50}	Median infectious dose; dose resulting in infection and illness for 50% of the exposed population
IPE	Individual protective equipment
J/cm^2	Joule per square centimeter

KIA	Killed in action
kg	Kilogram
kJ/m^2	Kilojoule per square meter
kPa	Kilopascal
LD_{50}	Median lethal dose; dose resulting in lethality for 50% of the exposed population
m	Meter
mg	Milligram
min	Minute
N/A	Not applicable
NATO	North Atlantic Treaty Organization
NBC	Nuclear, biological and chemical
N.O.E.	No observable effect
PAR	Population at risk
%BSA	Percentage body surface area burned to second or third degree level
PFU	Plaque forming units
RBE	Relative biological effectiveness
RDD	Radiological dispersal device
RTD	Return to Duty
S/S	Signs and symptoms
SEB	Staphylococcal enterotoxin B
SEIRP	Susceptible, Exposed and infected, Infectious, Removed, and Prophylaxis efficacious
STANAG	NATO standardization agreement
VEE	Venezuelan equine encephalitis
VX	O-Ethyl-S-(2-diisopropylaminoethyl) methyl phosphonothiolate
WEE	Western equine encephalitis
WIA	Wounded in action
WIA(1^+)	Wounded in action (Severity Level 1 (“Mild”) or greater)
WIA(2^+)	Wounded in action (Severity Level 2 (“Moderate”) or greater)
WIA(3^+)	Wounded in action (Severity Level 3 (“Severe”) or greater)

GLOSSARY

This glossary contains terms and definitions not provided in the body of the document or AAP-6; many other definitions are provided in section 1.4.

B

breathing rate. Also known as minute volume, this is the product of the number of breaths per minute and the volume of air inhaled per breath.

C

CBRN agent or effect. Chemical, biological, radiological, or nuclear materials used for or with the intent of causing damage or casualties. Chemical, biological, and radiological “agents” are materials physically present in the environment, while nuclear “effects” are energies emitted as a result of the detonation of a nuclear device.

concentration time (Ct). The integral of concentration in (mg/m^3) as a function of time (in minutes), also referred to as Ct (mg-min/m3). When Ct is multiplied by a breathing rate and the retention efficiency, the result is an inhaled dose.

D

defeat dose. The dose (or dose range) at which the efficacy of a medical countermeasure is no longer valid or applicable.

disease. An internal disruption of organ or system function, not caused by external trauma.

E

efficacy. The extent to which a medical countermeasure achieves its intended purpose when tested in a controlled environment.

I

icon. A group of individuals sharing a common location over time.

S

sign. A physical, objective manifestation of illness or injury, typically detected through the physical examination, laboratory tests, x-rays, or other medical tests.

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static overpressure. The pressure resulting from the blast wave of an explosion. It is referred to as positive when it exceeds atmospheric pressure and negative during the passage of the wave when resulting pressures are less than atmospheric pressure.

symptom. A symptom is a subjective indication of a disorder or disease, such as pain, nausea, or weakness. Symptoms may be accompanied by objective signs of disease such as abnormal laboratory test results or findings during a physical examination.

T

thermal fluence. The component of a nuclear detonation released as heat energy which strikes a surface and causes flash and flame burns; measured in kilojoules per square meter.

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14. ABSTRACT

This document is the second in a series of developmental draft documents leading to AMedP-7.5(A), the next iteration of the NATO CBRN casualty estimation methodology. This document presents the methodology as comprising four components—user input, estimation of the CBRN challenge, estimation of human response, and casualty estimation and reporting. This document fully describes the required inputs, the method of calculating the CBRN challenge, and the estimation and reporting of human response and casualties, including a dedicated section for each agent/effect describing how to estimate human response and casualties from that specific agent/effect. To increase user-friendliness, each dedicated section contains a flowchart for that agent effect instructing the user on which equations and lookup tables should be used, and the sequence in which they should be used. As this is a Study Draft, it has a few placeholders for agent-specific models, where model development or revision is ongoing. The final document will include 8 chemical agents, 17 biological agents, nuclear effects, radiological dispersal device isotopes, radiological fallout, and several illustrative examples.

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